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THE MARKINGS OF MARS.

ALFRED RORDAME.

A number of astronomical writers, in describing the markings of the planet Mars, treat the subject as though writing up an irrigation project in our own arid region. In writing glibly about this canal and that, these authors make no distinction between mere imaginary names and actual truth. The consequence is that the young and inexperienced observer, who would like to see with his own eyes the marvels that others claim to see, is disappointed and blames his telescope, eye, or the air at his station.

The fact that only a limited number of people are enabled to see the markings of Mars as straight lines intersecting one another in a geometric network, and the fact that observers with giant telescopes have failed to confirm the startling hairnet effect seen with smaller instruments, should at least make us skeptical as regards the actual form of the markings. The observers who draw canals on Mars apparently use a straightedge, treating the surface of the planet as a flat disc instead of a globe, as we know it is. This is no exaggeration on my part, for Professor Schiaparelli defines the "most perfect" type of canal as "a dark line (sometimes quite black), well defined, as it were drawn with the pen on the yellow surface of the planet." In this connection it might be interesting to quote a remark made by Dr. Lewis Swift to Capt. Noble: "Let me look," said Dr. Swift, "at Schiaparelli's map with a bright light for a while and then go to the telescope previously adjusted on Mars, and I see the canals just as marked on his map. After reading my circles a certain length of time with a bright light and then go to the telescope, I see the graduations on the sky, and they last for some little time. It has occurred to me that some or all of the canals seen by many may be caused in the same way."

E. M. Antoniadi, F. R. A. S., one of the most experienced of modern observers, states that "under no circumstances whatever can I keep a Martian canal steadily before me. At best, the canals appear to me

invariably by glimpses only, every glimpse rarely lasting more than a small fraction of a second. Rev. T. E. R. Phillips, F. R. A. S., states, "Faint markings have been glimpsed now and then, and it would be easy, by the scientific use of the imagination, to conjure them into lines and streaks harmonizing with Schiaparelli's charts."

Thus we see from these quotations that, notwithstanding Professor W. H. Pickering's dictum that the canals are easily visible in his 3-inch finder, in reality they are seen with the greatest difficulty in telescopes of 9½-inch aperture. Personally, observing with telescopes, both refracting and reflecting of from 4¼-inches to 16 inches, I have never been able to see these markings excepting as boundaries of areas of different albedos. This also bears out the statement of N. E. Green, F. R. A. S., whose drawings of Mars have never been surpassed: "I have been deceived sometimes by the edges of faint tones, and have drawn them with a single line, only to find out my mistake when the form came to the meridian, and its whole shape was made evident."

Of the real nature of the markings termed canals, I maintain that we still know very little, though the explanation quoted below, and which was put forward some years ago by Maunder, is deserving of consideration:—"Experiments made some years ago on the limit of sight, without optical aid for small objects, demonstrate that whereas the smallest dot that one can clearly see with the eye must subtend an angle of about 40 seconds, I was perfectly conscious of the existence of a line when it only had a breadth of about eight seconds. At the same time it could not be called distinct vision; I was conscious of the line, but it was not sharply defined on the eye. The reason, I suppose, was that the dot simply affected one element of the retina, 40 seconds being about the diameter of the rods of the retina, whilst the line passed over a number of them, and so produced a certain indistinct but appreciable effect. It seems to me, therefore, that if we have on a planet or any celestial object a number of small markings, each of them individually below the limit of distinct vision, we might very easily get the effect of narrow straight lines, and from the beginning of the controversy as to the canals of Mars it has seemed to me that a good many of them probably owe their existence to something of the sort. The observers are really trying to form a distinct impression from the confused result of an aggregate of *minute* markings, each of which is individually beyond the power of the eye to grasp."

Professor Barnard when at the Lick Observatory in the early nineties devoted a great deal of his time to the observation of Mars with the 36-inch refractor, and has the following to say of the more permanent dusky markings variously called seas, marsh, etc., and supposed to be areas of permanent vegetation:—"Under the best conditions these dark

regions, which are always shown with smaller telescopes of nearly uniform shade, broke up into a vast amount of very fine details. I hardly know how to describe the appearance of these 'seas' under these conditions. To those, however, who have looked down upon a mountainous country from a considerable elevation, perhaps some conception of the appearance presented by these dark regions may be had. From what I know of the appearance of the country about Mount Hamilton, as seen from the observatory, I can imagine that, as viewed from a very great elevation, this region, broken by canyon and slope and ridge, would look just like the surface of these Martian 'seas'."

Salt Lake, Utah.
Jan. 28, 1917.

THE ASTRONOMER.

City traffic with its thunder
Made him blink and think and wonder,
With its roaring and its pouring,
As it rumbled down the ways,
Where the crowds go ever streaming
In an endless effort seeming
Like a swirling, whirling maelstrom,
In a tangled moving maze.

And he watched the rush and hurry
Of the vast, titanic flurry,
While he walked in humble tribute
To the city's might and power,
With the busy, dizzy buildings,
And the ever changing gildings
Of the glowy, showy light signs
That make gay the midnight hour.

But tonight, within a small room,
Just a single little hall room
Where the riot sounds are quiet,
He has settled down to trace
On a chart the swinging far path
Of the solar system star path,
And the city's size is shrinking
As he's thinking out through space.

He has changed his former notion;
Like an atom in an ocean
Seems the city he could pity
For the littleness of it;
For within this tiny hall room,
From this meagre, cell-like small room,
He is ranging through the space fields
Where the flaring comets flit!

GEORGE B STAFF.

Franklin, Ind.

THE SOUTH POLAR ECLIPSE OF 1917 DECEMBER 13*.

WILLIAM F. RIGGE.

If there is anything in the whole realm of the wonderful science of astronomy that commands the admiration of the world, learned as well as unlearned, it is the accuracy with which eclipses are predicted, and the precision with which the time and the track of a total eclipse of the sun are laid down upon the surface of the earth decades of years, I might probably say centuries, in advance. People wonder how it is possible that an astronomer may travel thousands of miles, carrying with him all kinds of instruments, may spend weeks in their erection and adjustment, and when the predicted moment has come, may secure such valuable and accurate results as if he had been at home in his own observatory, had used his own familiar and permanently mounted equipment, and had arranged the time of totality to suit his own convenience. Truly, there is reason to marvel at this great God-given intelligence. But, humanly speaking, astronomers have deserved it, they have paid for it by their centuries and even milleniums of patient observations, analyses and computations. And there is no doubt that other sciences will attain similar results when they shall have been studied with similar assiduity, and we feel assured that with our modern facilities of research and communication the time and labor will be much reduced.

The idea here expressed finds a practical application in an eclipse of the sun, which will occur in 1917 on December 13, and whose central line will lie exactly across the south pole. I use the word "exactly" designedly, and because it is somewhat flexible in its meaning, I will later on show in what sense it is employed, and I can promise that there will be no disappointment in its use.

The fact of the central line's lying across the south pole brings in its train many other exceptional circumstances, such that the eclipse will be visible in all longitudes and at all hours of local time, at noon and at midnight, at sunrise and and at sunset. Although the eclipse is not a total one, but only annular, the obscuration will reach 97½ per cent, and on the central line the sun will appear as a beautiful and slender ring of light whose width is one-eightieth of its diameter.

* Read at the New York Meeting of the American Astronomical Society, December 28, 1916.

Fig. 1 will introduce us to the general features of this eclipse. Here we see the hemisphere that is presented to the Sun on December 13 at $21^h\ 55^m$ Greenwich mean time, that is, on December 14 at 3:55 A. M. central time. The Sun is directly overhead in the center of the Earth's disk, in latitude 23° 12′ South and in longitude 30° East. The straight line AB is the path of the Moon's center as seen from the Sun, and is drawn exactly through the earth's south pole. The circle centered at $21^h\ 55^m$ is the Moon's penumbra, within which the Sun appears to be more or less eclipsed. The line CD, parallel to AB, is the Northern Limit of the eclipse, and, if the Earth did not rotate, would show us at a glance the entire region within which the eclipse would be visible. But because the earth does rotate, the straight line CD is bent into the curved line that we see near it in the figure.

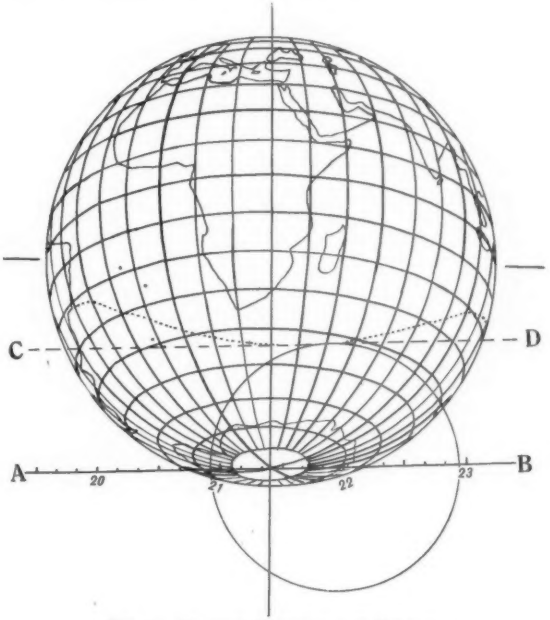


Fig. 1. General View of the Eclipse.

As the path of the penumbra's center across the south pole and in its immediate vicinity is the special feature of this eclipse, the following figures in this article will give us first a three-fold, then a thirty-fold, and lastly even a three hundred-fold enlargement of this part of Figure 1. But before we pass over to them, we must study what to us in the northern hemisphere may appear a topsy-turvy orientation.

Let us imagine ourselves standing on the Earth at the very top of Figure 1, that is, in latitude 66° 48′ north and in longitude 30° east. Let us also either suppose the Earth's rotation arrested for a while, or else travel with the rapidity of thought. As we look at the Sun from the place mentioned, we see it just above the south horizon at noon. The cardinal points N S E W on its disk will then appear as in Fig. 2a, and will coincide exactly with T B L R (top, bottom, left, right) as in Fig. 2b. We may therefore conceive these two figures superposed one upon the other. They have been drawn separately for the sake of clearness and for a reason to be mentioned presently.

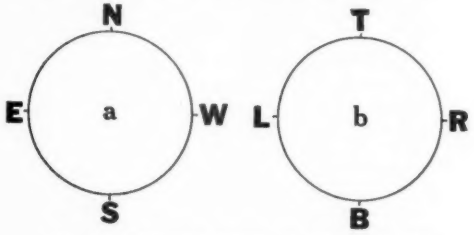


FIG. 2. REFERENCE POINTS ON THE SUN'S DISK.

As we travel southward on our selected meridian of 30° east, the Sun will be a degree higher in the sky at noon for every degree of latitude we cover, until it will be in the zenith when we arrive at 23° 12′ south latitude, in the very center of the Earth's disk as shown in Fig. 1. If we were to hold the two superposed diagrams of Fig. 2 just before us when looking at the Sun, at such a distance and such a manner that the diagram would be as large as the Sun in the sky and exactly cover its image, we would begin in latitude 66° 48′ north by holding the paper vertically, then as we travelled southward we would raise the paper higher and higher in a circular arc, keeping E W and L R horizontal but inclining N and T forward, thereby lowering them and raising S and B, until when the Sun was directly over our head the cardinal points N S E W would be the same as ever but T B L R would lose their meaning altogether.

On continuing our southward journey, always holding the diagram before the Sun in the sky, we begin to lower the paper behind our back, and when we now turn round to get a more natural look at it, we find that T B L R have turned around with us but N S E W have not. In a word, as soon as we cross the latitude which has the Sun in its zenith, the relative or local designations of top and bottom, right and left have turned halfway round on the Sun's disk, while its cardinal points, north, south, east, west, have remained the same. That is, we have now learned that N S E W are fixed points on the Sun's disk

itself, while T B L R are dependent upon our place of view on the Earth.

We get a further confirmation of this lesson when we look at the Sun when it is off the meridian, that is, in the forenoon or in the afternoon. We always place T on top of the Sun's disk as we see it, no matter where on earth we may be. But N will not be on top for us in the United States except at noon and at midnight. Before noon N inclines to the left, and afternoon to the right, by an amount which depends upon three factors, the Sun's declination and hour angle and our latitude.

We are now convinced that in the southern hemisphere beyond the tropics, at least, the Sun's uppermost point at noon is its south point. May we now advance still further south on our journey? We have turned round to look at our diagram and the Sun. Fig. 2a has remained the same on our paper but Fig. 2b has been superposed upon it reversed, or rather it might be better to say that as we now look at our paper, T B L R are the same but N S E W have been all reversed. As we proceed southward, we keep on lowering our diagram to a more convenient height. But what happens the moment we cross the south pole? Shall I let the reader wrestle with the problem, or mercifully save him the suspense and the uncertainty? Well, nothing happens, except that our paper is lowered a degree for every degree of latitude we make, and that we are now going north on the Earth. But N S E W and T B L R remain exactly as they were before we passed the south pole, and they will remain so until we reach the latitude 66° 48′ south beyond the south pole which is the lowermost point of the Earth's disk on Fig. 1.

This reversal of the nomenclature of points on the Sun's disk may be brought about in two ways. The way we did it was to travel along a meridian across the place which had the Sun in its zenith. It is the Sun's crossing the zenith, therefore, and not its declination that determines this reversal, and hence this reversal must take place everywhere within the tropics twice a year whenever the Sun's declination equals the latitude of the place. The second way would be to pass through the place that has the zenithal Sun by travelling in an east and west direction, or rather to remain at rest in the place and allow the Earth's rotation to apparently move the Sun for us from the east through our zenith to the west. The moment before this transit through our zenith, that is, the moment before our local noon, the point T would fall upon W, at noon itself all the points T B L R would vanish, and the moment after noon T would fall on E. Should the Sun's center cross our meridian slightly south of our zenith, there would be a correspondingly rapid run of the point T from W through N to E, should

it cross north of our zenith T would run through S. All these facts may be satisfactorily understood with the help of a celestial globe. We shall need many of them in our study of this South Polar eclipse.

We are now prepared to examine Fig. 3, which is a map of the region within 30 degrees of the south pole and gives all the data pertaining to the beginning of the eclipse. The outer circle represents the latitude of 60° south, the next, the broken one, is the Antarctic Circle; then come the latitudes of 70° and 80°. The meridians are drawn at intervals of 30 degrees, 30 degrees east longitude being on top in all the maps in this article. Fig. 3 is a three-fold enlargement of the south

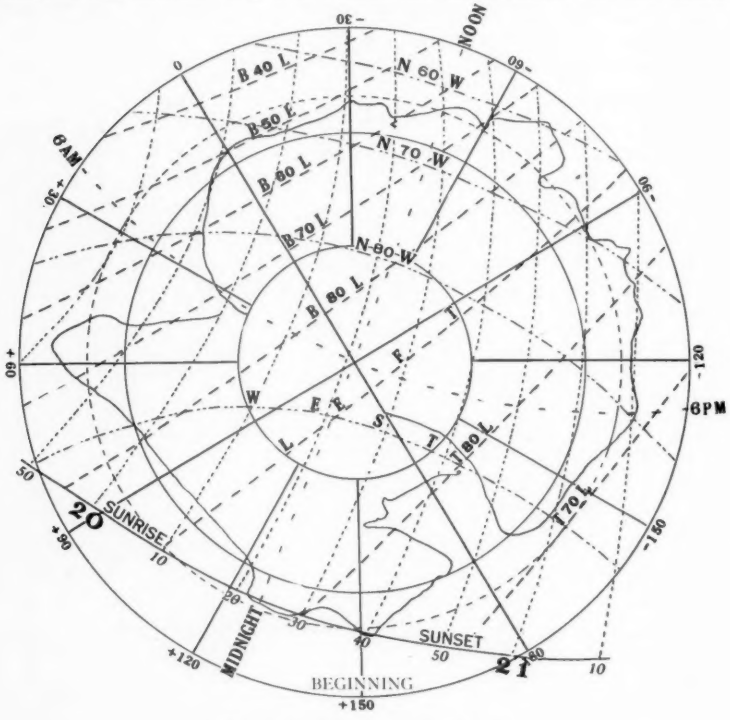


FIG. 3. BEGINNING OF THE ECLIPSE.

polar region of Fig. 1, with the obvious difference that in Fig. 3 the south pole is in the center of the map. The lower curve marked with the words Sunrise and Sunset, and with the large numbers 20 and 21 and the smaller ones 10, 20, 30, 40, 50, shows the lines along which the Eclipse will begin at local sunrise and sunset. The large numbers mentioned give the hours in Greenwich time and the smaller ones the

preceding and following ten minute intervals. The dotted lines running almost at right angles to the Sunrise and Sunset line carry these times across the whole map, so that by estimation the time of the beginning of the eclipse may be found to the nearest minute anywhere within the South Frigid Zone. From the word NOON to the pole the eclipse will begin at local noon, and similarly for the lines indicating MIDNIGHT and 6 A. M. and 6 P. M. Along the curve marked WEST

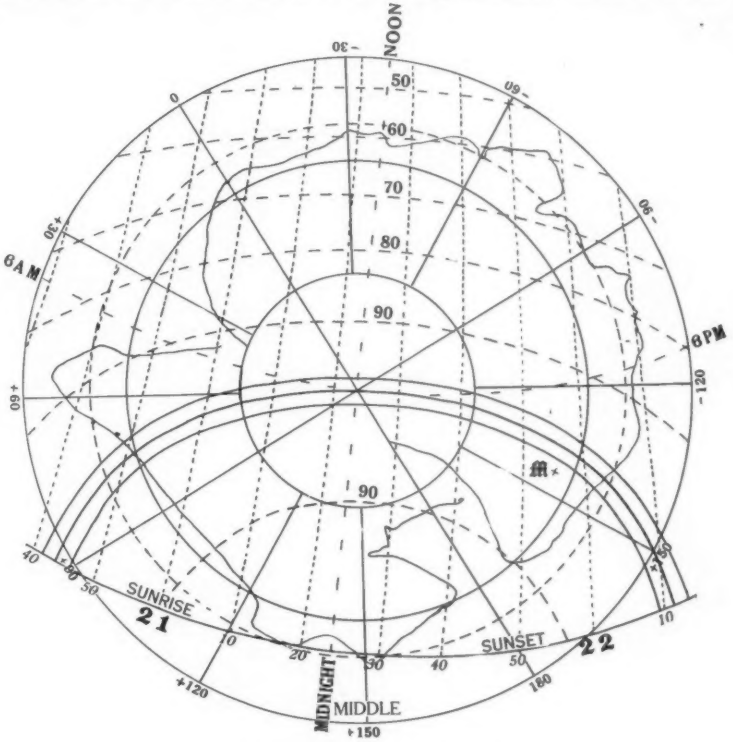


FIG. 4. MIDDLE OF THE ECLIPSE.

the Moon will be seen to first indent the Sun at its West point. Along the line N 80° W the first contact will occur 80 degrees from the Sun's north point towards the west, and in like manner for N 70 W and N 60 W. On the curve marked LEFT the first contact occurs on the left side of the Sun, for T 80 L it occurs 80 degrees from the top or uppermost point towards the left, and for B 80 L it is 80 degrees from the bottom or lowermost point towards the left.

If we now examine the map in Fig. 3 more closely, we will see the

curve N 60 W intersecting the curve B 60 L on the noon line, because, as we said before, in the southern hemisphere beyond the tropics the Sun's north point N always coincides with its lowermost point B at local noon, and W with L. For the same reason N 70 W intersects B 70 L, and N 80 W cuts B 80 L on the noon line, and WEST cuts LEFT on the midnight line. And a still closer study of the map will show us that the N and B points on the Sun's limb are farthest apart on the 6 A. M. and 6 P. M. lines, and that this separation is nearly equal to the colatitude of the place.

Fig. 4 gives the data for the middle of the eclipse. The Sunrise and

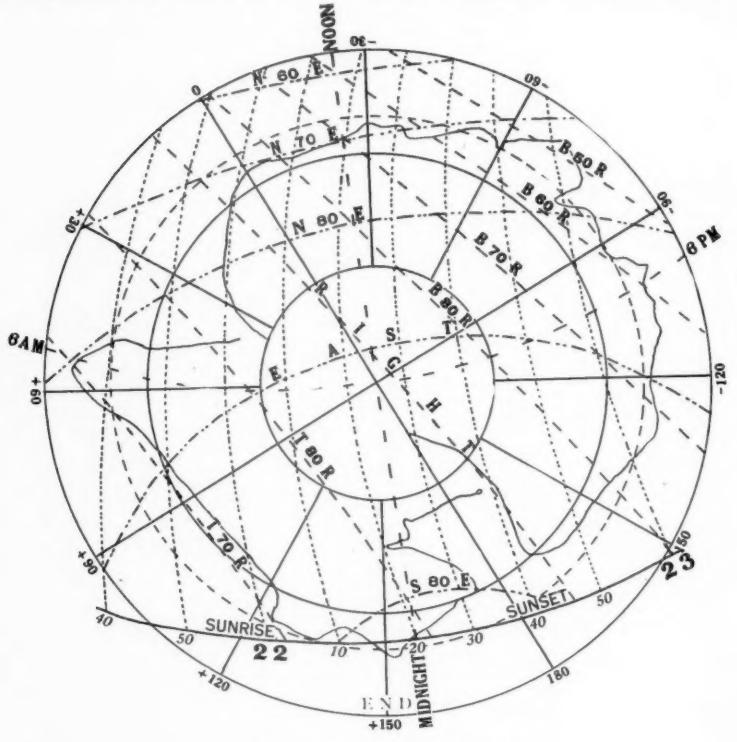


FIG. 5. END OF THE ECLIPSE.

Sunset, the Noon, Midnight, 6 A. M. and 6 P. M. lines indicate that the middle of the eclipse, that is the maximum obscuration, will occur at these local times, while the dotted curves as before show the Greenwich times for every ten minutes. The three close parallel lines show the path within which the sun will appear to be annularly eclipsed,

that is, the Moon will be completely before the Sun but unable to obscure it completely. Along the central line which we see running exactly across the south pole and not far also from the Magnetic Pole at x near the Gothic M, the Moon will be placed centrally before the Sun. The other lines marked 50, 60, 70, 80, 90 indicate the magnitude of the eclipse, that is, the per cent of the Sun's diameter obscured. This obscuration is 96.7 per cent at the beginning of the annular path on the sunrise curve, 97.5 per cent at the south pole, and 96.9 at the end of the path on the sunset line.

Fig. 5 shows the same data for the end of the eclipse that Fig. 3 did

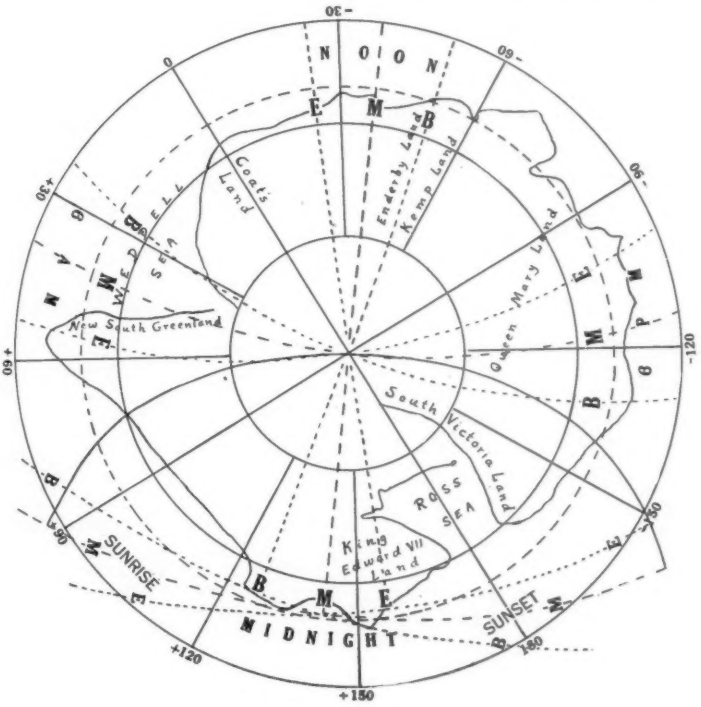


FIG. 6. SUMMARY.

for its beginning. Fig. 6 summarizes some of the more important findings of the three preceding figures. In the sector marked NOON some phase of the eclipse takes place at local noon, along B the eclipse begins, along M it is at its middle, and along E its ends. The same applies to the other sectors. The regions have been named and the whole map taken from the article "Shackelton's South Polar Expedition" by

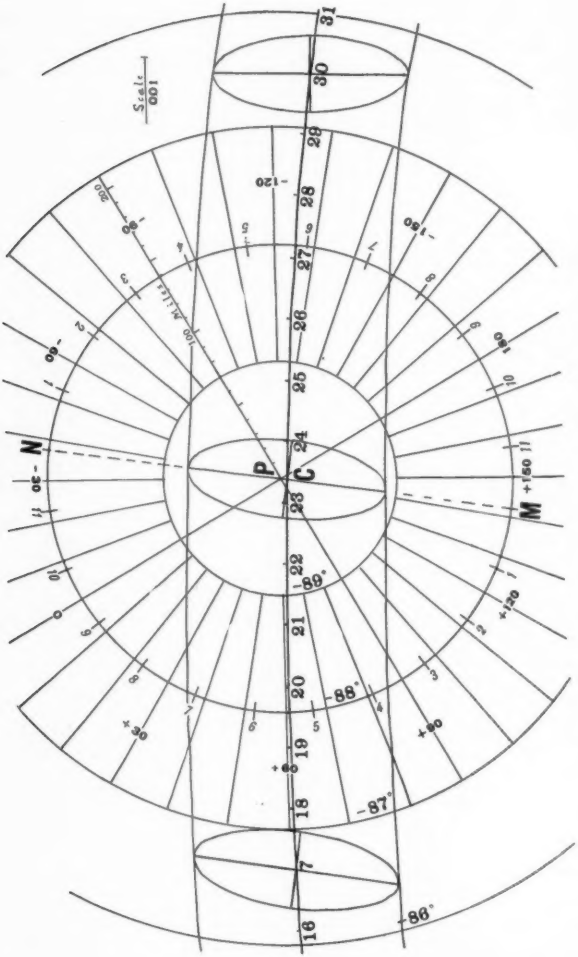


FIG. 7. THE CENTRAL LINE NEAR THE POLE FOR EVERY MINUTE.

Henry Arctowski, in the Scientific American of June 17, 1916, where it is called Professor David's sketch map.

We will now examine the map near the south pole under a higher magnifying power. Fig. 7 is a ten-fold enlargement of the central parts of Figs. 3, 4, 5, 6. The latitude circles are now drawn for every degree and the meridian lines for every ten degrees. There is a scale of miles along the longitude 90° E. The band across the middle of the map is the Annulus Path, within which the Sun is seen to be annularly eclipsed, centrally of course, along the Central Line, which gives the position of the center of the so-called Negative Shadow for every minute from $21^h\ 16^m$ to $21^h\ 31^m$ G. M. T. The three ellipses are instantaneous outlines of the Negative Shadow at 17^m, $23^m\ 24^s$, when its center is at C nearest the pole P, and at 30^m. The Central Line now appears to

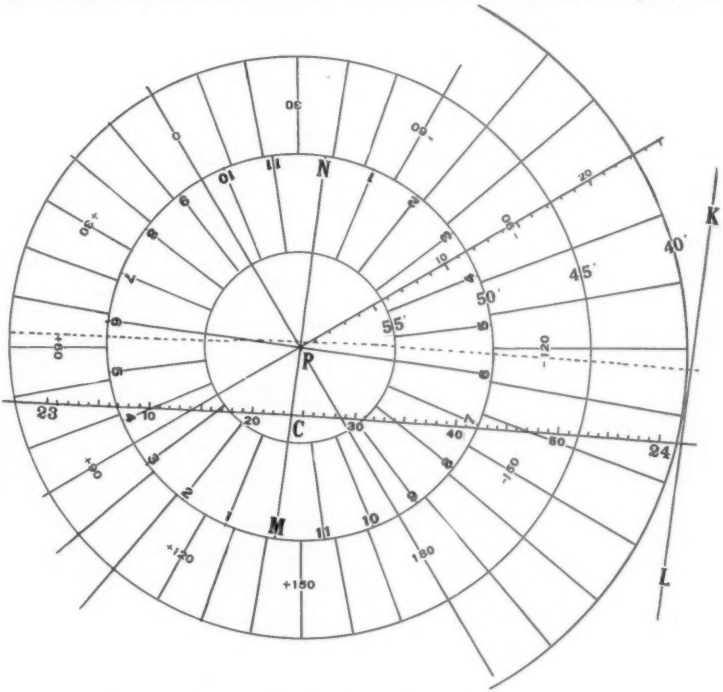


FIG. 8. THE CENTRAL LINE NEAR THE POLE FOR EVERY SECOND.

pass near the pole but not *exactly* through it. Let the reader kindly withhold his judgment for a while until we have fully stated the case.

Fig. 7 shows another interesting item, the time dial, which is set for the time $21^h\ 23^m\ 24^s$ when the center of the Negative Shadow is near-

est the pole. N means local noon, M midnight, and the numbers the full hours. But this time dial is in rotation on the earth, while the meridian lines are fixed and at rest. The local 6 P. M. line, if drawn would cut the Central Line at $24^{m}.5$, about one minute after the time for which the dial has been drawn, so that it would not have turned noticeably. But the 6 P. M. line if extended towards the right would seem to cut the Central Line again at some point far off the diagram. But as was said, the time dial is in rotation counter-clockwise, so that this second point of intersection occurs in reality at $30^{m}.95$, just within the limits of Fig. 7.

We are now coming to the most interesting feature of the present eclipse. Fig. 8 is a ten-fold enlargement of the central part of Fig. 7, and hence a three hundred-fold magnification of a part of Fig. 1. The

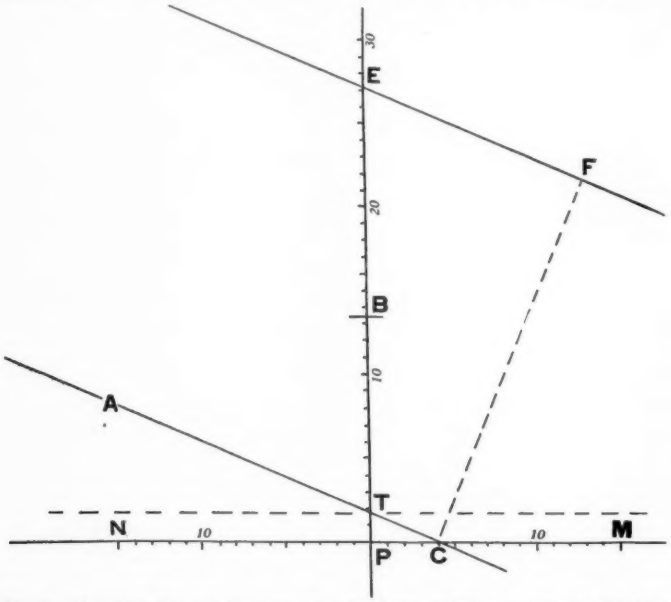


FIG. 9. VERTICAL SECTION THROUGH THE AXES OE THE EARTH AND THE SHADOW.

latitude circles are now drawn for every five minutes, and the longitudes are marked for every ten degrees north of the parallel of 89° 50′ south. On longitude −90° we have again our scale of miles. The line K L is the preceding edge of the Negative Shadow, its following edge being off the map altogether on the left. Inside of the circle of 89° 50′ we have the time dial, which may be said to be fixed during the minute that the center of the Negative Shadow runs from 23 to 24 on the

diagram. The numbers 10, 20, 30, 40, 50 and the intervening marks show the single seconds after 23 minutes. The reader may see for himself with what speed the shadow runs through the longitudes and the local times. But the Central Line at C seems farther than ever from the pole P. In fact, measurement will show it to be 4.0 miles away. Is the case lost? Have we trifled with the word "exactly"?

Let us look at Fig. 9, which is a vertical section through the axis of the Penumbra when it is nearest the pole, and is on the same scale as Fig. 8. The lines N P C M and the points P and C are identical on both figures, so that Fig. 9 may be conceived to be set up vertically over Fig. 8. N is the noon and M the midnight side of the pole, and the marks on N M indicate miles. A T C is the axis of the Penumbra and the Shadow, it is the straight line joining the centers of the Sun and Moon at the given moment, $21^h\ 23^m\ 24^s$ G. M. T. E F is the Southern Limit of the Negative Shadow, and when revolved about A C will cut Fig. 8 on the line K L. The angle A C P is the Sun's altitude as well as its declinatian, 23° 12′.

The axis A T C of the Shadow cuts the prolongation of the Earth's axis P T B E at the point T, 1.725 miles or 9107 feet above the pole P, and intersects the horizontal plane through P at the point C, 4.0 miles or 3′.48 beyond the pole on the midnight side. Four miles beyond the pole! Is that passing *exactly* through the pole? Tarry a little; there is something else. What do we mean by the word "south pole"? We all answer at once, the south end of the earth's axis of revolution. I ask again, where is this end? Why, on the ground, of course. Aye, there's the rub! Where then is the ground at the South Pole? Is it at sea level, as all our figures have so far implicitly taken for granted? We know, of course, that the earth is not a perfect sphere, for if it were, the south pole would be at B in Fig. 9, 13.3 miles above the point P. But we also know from the reports of Amundsen and Scott that the south pole is in the middle of a large continent called Antarctica and on a lofty plateau *about ten thousand feet high.* Now this elevation of a few thousand feet is of vital importance in the present eclipse on account of the low altitude of the Sun. Look at the broken line parallel to N M on Fig. 9. It is ten thousand feet above the sea level line P C and when transferred to Fig. 8 is the dotted line passing only about half a mile from the pole and on its *noon* side, instead of four miles away on the *midnight* side as the sea-level Central Line does. As the ground is *about* ten thousand feet high and is not likely as true a level surface as a body of unfrozen water, have we not very great probability in our favor when we say that the pole itself is 9107 feet above sea level and that the Central Line passes *exactly* through the "pin-point" of the pole? And I challenge all doubters to go and dis-

prove the assertion by observation.

Here I must acknowledge my indebtedness to Mr. C. T. Whitmell, M. A., B. Sc., who first mentioned this most remarkable feature of the present eclipse in the Monthly Notices of the Royal Astronomical Society, LXXVI, 408. And it is only because he contented himself with a few numerical statements and gave no diagrams or maps whatever, that the present article took its origin and led to the construction of its many diagrams. All the data presented on these figures were obtained graphically from an enlargement of the lower part of Fig. 1, all, I say, except those pertaining to the Central Line and the Annulus Path. The American Ephemeris, which was my sole source, gives merely the beginning, middle and end of the Central Line and the points of First and Last Contact, which we did not need in the present article. How reliable my source is may be evinced by the French eclipse of 1912 April 17, when the American line came nearest to the observed one. (*The Observatory* **449** 226). I will conclude by giving the results of my numerical computations and a drawing of the eclipsed Sun, Fig. 10, as it will appear at the South Pole.

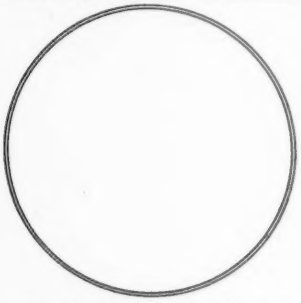


FIG. 10. THE ECLIPSED SUN AS SEEN AT THE SOUTH POLE.

THE CENTRAL LINE OF THE ECLIPSE.

Greenwich Mean Time G. M. T.	Latitude	Longitude	Longitude of Central Meridian	Local Hour Angle	Local Apparent Time
	ϕ	λ	μ	τ	τ
h m	° ′	° ′	° ′	° ′	h m
20 43.8	−59 1.9	+ 87 52.7	−47 41.0	−135 13.7	2 59.1 A.M.
20 50	69 20.0	74 28.6	46 8.1	120 36.7	3 57.6
21 0	76 38.0	67 35.9	43 38.1	111 14.0	5 15.1
10	82 41	63 6.9	41 8.1	104 15.0	5 3.0
17	86 38	60 35.6	39 23.2	100 18.8	5 18.7
18	87 8.7	60 34.3	39 8.2	99 42.5	5 21.3
19	87 43	60 30.0	38 53.2	99 23.2	5 22.4
20	88 11	60 35.9	38 38.2	99 14.1	5 25.0
21	88 45	61 51.8	38 23.2	99 15.0	5 23.0
22	89 16.3	62 27.1	38 8.2	100 35.3	5 21.7
23	89 46.7	73 25.9	37 53.2	−111 19.1	4 34.7 A.M.
23.40	89 56.6	+142 12.8	37 47.2	±180 0.0	Midnight
24	89 41.2	−133 58.6	37 38.2	+ 96 20.6	6 25.3 P.M.
25	89 10.1	126 49.1	37 23.2	89 25.9	5 57.7
26	88 39.7	125 40.0	37 8.2	88 31.8	5 54.1
27	88 7.5	124 55.0	36 53.2	88 1.8	5 52.1
28	87 36.6	125 17.5	36 38.2	88 39.3	5 54.6
29	87 4.9	125 7.2	36 23.2	88 44.0	5 54.9
30	86 28	125 29.4	36 8.2	89 23.4	5 57.6
40	81 17.1	128 46.4	33 38.2	95 8.2	6 20.6
50	75 42.1	132 53.7	31 8.3	101 45.4	6 47.0
22 0	69 43.1	137 33.8	28 38.3	108 55.6	7 18.7
10	58 49.3	151 9.0	26 8.3	125 0.7	8 20.0
10.5	−56 7.8	−155 41.2	−26 0.8	+129 40.4	8 38.7 P.M.

THE CORDOBA DURCHMUSTERUNG.

R. H. TUCKER.

The fourth volume of the Cordoba Visual Durchmusterung has recently been published and distributed. It covers the area from 52° to 62° south declination, and contains the last observations made by Dr. J. M. Thome, late Director of the Argentine National Observatory, who died in 1908.

The four volumes completed at Cordoba cover the region −22° to −62° in declination, an area of about 10,500 square degrees, or one half the area south of the equator. With the northern Durchmusterung of Argelander, and the continuation by Schönfeld to −23°, all but about one seventeenth of the whole sky has been observed visually.

The Photographic Durchmusterung, completed at the Cape of Good Hope under Gill, and reduced by Kapteyn, from −18° to the south pole, covers two-thirds of the southern sky, and has already filled this gap on a similar plan, photographs in place of visual observations. The two schemes supplement each other, and the photographic magnitudes, based upon the visual estimates of Gould's Cordoba Zones, can be compared with the visual magnitudes, for stars not previously observed.

In the Durchmusterung of the sky, the scale of magnitudes and the completeness of the enumeration are the most important points.

The visual census of the southern sky had been one of the plans of Dr. B. A. Gould, the first Director of the Observatory, and it was undertaken by his successor in 1885, when the Zones and the General Catalogue had been completed. Both Thome and Tucker observed throughout the first twenty degrees of declination, which form the first two volumes, in the proportion of two-fifths and three-fifths, respectively. Seven years were spent in the observations of this portion, of which the last two years were devoted to a careful revision of all doubtful cases of magnitude or identity, by direct comparison with the sky. The following twenty degrees were observed mainly by Dr. Thome, and required some fifteen years for completion. The total number of stars catalogued is 580,000 in round numbers, representing the painstaking labor of nearly a quarter of a century for one of the original observers.

The scheme of observation has undergone some slight changes. The first two volumes are perfectly homogeneous in plan, the observations

were made with a dark field, and the object was to include all stars of the visual tenth magnitude. To secure this object, many stars were listed fainter than tenth, especially in the sparsely populated regions. The faintest estimate, 10, is then a flexible grade, intended to include all the faintest stars that were observed.

Argelander's design was to include all stars of the ninth magnitude, and his lowest estimate is 9.5, which was also a flexible grade, covering the faintest stars observed, some of which are close to the tenth magnitude. His magnitude 9.4 is the faintest that can be counted as an actual estimate in all cases. The Cordoba 9.9 stands in the same relation to its own scale. Schönfeld probably includes all stars of 9.5, and his lowest estimate is 10. The photographic enumeration claims to be complete to about nine and a quarter, and extends to much fainter magnitudes, for partial enumeration.

In the continuation of the Cordoba Durchmusterung south of $-41°$, Dr. Thome adopted some illumination of the field of the telescope, for his own work, which made up the greater part of the third volume. This was designed to improve the precision of the observation of positions. The limit of brightness has not apparently been affected by the illumination, as the number of stars included per square degree is actually slightly in excess of that of the two preceding volumes. But the scale of magnitudes of this volume, for stars of ninth magnitude and brighter, certainly was changed at this time, and the estimates are about a half magnitude fainter than in the preceding work. A few estimates fainter than ten were included in the published catalogue.

In the fourth volume, estimates are included as faint as twelve of the visual scale, though but few of the extreme grade are published. This would be nearly the limit of visibility in his five-inch telescope, with a dark field. For stars fainter than ten, the magnitudes are printed in quarters; while all the stars of the three preceding volumes are listed in tenth's of a magnitude, each value being the mean of two or more original estimates to quarters. In this last volume the proportion of stars to a square degree drops quite decidedly, from 61 at $-51°$, to 48 at $-52°$. The proportion of ninth magnitude to a square degree is half way between that of the first two volumes, and that of the third volume.

Counts and percentages of the stars of various grades of magnitude can be employed profitably in checking the system of magnitudes, and the limit of the stars included, taking a catalogue of this character by itself, without other basis of comparison. The assumptions at the foundation of such comparisons are that stars of all grades are approximately well distributed through space, and that the apparent brightness is a function of distance.

To put these assumed laws into convenient form, we would have the summation of visible stars to any limit of magnitude represented by the expression:

$$\Sigma = a\, b^{m}$$

where both a and b are constants to be empirically determined by counts actually made. Or, we can fix the value of b by the adopted ratio of brightness of the visual scale for the difference of one unit of magnitude. If this value δ be taken at 2.5, then $b = \delta^{3/2} = 3.95$, and we can form the ratios of the summations of all the stars to any limit of magnitude. The fact that b tends to diminish very decidedly, as we reach the faintest grades of stars in actual counts, shows that space is not entirely filled with the same proportional mixture of all grades of stars; in other words, there is a finite limit to this universe of stars, not far beyond the reach of our largest telescopes, or of long exposures with sensitive photographic plates. The expression above has been found to provide good confirmation of the old visual scale to ninth magnitude; and it can safely be used down to the limit of the stars included in the Durchmusterung.

For the purpose of using it in this way, a tabulation of the ratios of the respective summations to differential grades of the visual scale is given below. For a difference of magnitude, the ratio of stars included is given, for each tenth, up to a difference of two units.

TABLE I.

Δ	Σ	Δ	Σ
0.1	1.15	1.1	4.5
0.2	1.32	1.2	5.2
0.3	1.51	1.3	6.0
0.4	1.73	1.4	6.9
0.5	1.99	1.5	7.9
0.6	2.28	1.6	9.0
0.7	2.61	1.7	10.3
0.8	3.00	1.8	11.8
0.9	3.44	1.9	13.6
1.0	3.95	2.0	15.6

The ratios at the quarter magnitudes would be; 1.4, 2.0, and 2.8, respectively. These tabulated ratios will be found useful for comparing the summations of two different catalogues, as a test of their respective magnitude scales, as well as for the testing of an individual scale in various parts.

Different areas of sky present a great variety in total distribution of stars, but zones carried around the sphere may include about the same alternation of thickly and sparsely populated regions, and the mixture of stars of all grades of brilliancy will be similar for zones of sensibly

large extent. In comparing similar lists, over the *same* area of sky, the ratio of numbers to any given grade is an excellent test of the magnitudes.

The following tabulation gives the total number of stars per square degree, in several authorities, and also the average number to the ninth magnitude. The ratio of the two numbers gives the equivalent summation, each on its own scale. It will be noted that in order to secure completeness to any definite limit, the faintest stars are much below that limit; and, in fact, the faintest stars will be below the grade of the equivalent summation. Thus, Argelander aimed to include all of 9.0, his total number is equivalent to that of all stars to 9.8, and undoubtedly stars of tenth magnitude would be included in his lowest flexible grade. The table includes the computed grade of the Harvard photometric scale, for the 9.0 of each authority, based upon Table I above. Thus, Argelander's 9.0 would be found at 9.3 of the photometric scale.

TABLE II.

Catalogue	Stars	9.0	Limit	Σ	9.0 H. P
Argelander Nor. D. M.	15	4.90	9.5	9.8	9.3
Schönfeld S. " "	18	4.65	10	10	9.25
Cordoba III " "	56	6.7	10	10½	9.5
" III " "	61	3.7	10	11	9.1
" IV " "	46	5.2	12	10½	9.35
Cape Photog. " "	32	5.85	Var.	10¼	9.45
Harvard Photom.	—	3.26	9.0	—	—
Gould's Zones	6	—	10	—	—

The numbers for the Photographic Durchmusterung are the average for the whole area, and there is very great variation in different parts. Attention was called to a break in continuity at $-34°$, in discussing the relation of the photographic, and the visual work of the first twenty degrees of Cordoba, in a note in the *Astrophysical Journal*, Vol. VII, No. 5, for May 1898. The number per square degree rose from 22 to 32 at this point, but the scale of magnitudes suffered no perceptible change. In the zone covered by the fourth Cordoba volume, the photographic has 48 to the square degree, there being a distinct break at $-58°$, where the average drops from 52 to 42, without there being any indication of a similar change in the visual enumeration at that point.

Argelander observed with a three inch telescope, capable of showing eleventh magnitude stars in a dark field. His colleague Dr. Schönfeld, who had taken part in the northern work, when he began the extension south used some illumination for his six inch telescope, but stars of the twelfth magnitude would possibly have been visible under good conditions. The low altitude at which he was obliged to observe would cut

down the visibility, to some extent. During a visit to him in 1889, while our work at Cordoba was in progress, I had an opportunity to see the telescope—historical in interest—with which Argelander began the first Durchmusterung.

The Harvard photometric numbers are based on the count of photometer measures of magnitude, and the ratio of increase in the numbers of stars is smaller than that of the assumed law of distribution which we have used in this comparison. The photometric magnitudes represent a fainter scale of estimates than those of the visual scale, judging by the summation of stars included. The relation between the numbers of ninth magnitude stars in the various authorities can still be accepted, however, as a test of the difference of magnitude scales, when the authorities include complete enumeration of stars of the classes compared. Gould's zones are not actually complete to any definite magnitude, but his proportion of stars to a square degree would indicate an equivalent number below the 9 of Argelander, and below the average 9 of the four Cordoba volumes. In the selection of the stars from Gould's zones, for the reduction of the observations of the first twenty degrees, I found nearly invariably that our estimates were brighter, from a quarter to a half magnitude as a rule. The magnitudes of the third volume are distinctly fainter than Gould's estimates. In the fourth volume they should be about the same. Gould probably has a small proportion of stars fainter than 9, judging by the photographic and visual averages of ninth magnitude stars.

The fourth volume of the Cordoba Durchmusterung can be subjected to tests of its magnitude scale, and its limit of stars, similar to those made for the preceding volumes. In Table III, below, the count and percentages are given for the single degree, −57, which may be taken as typical of the ten-degree zone, as it is half way in arc, and the count of stars and average per square degree are near the respective means. It was probably observed near the mean epoch, also.

TABLE III −57°

To mag.	7.0	Σ 56 = 0.0063
	8.0	265 = 0.0296
	9.0	1003 = 0.112
	10	4675 = 0.522
	11	8483 = 0.95
	12	8950 = 1.00

The ratios for the summations of the first four grades are 4.7, 3.8, and 4.7, respectively, which would indicate that the fainter stars were estimated slightly too bright, on the scale of the brighter stars. The summation to tenth magnitude would be equivalent to 10.1 of the scale above

the tenth; and the two fainter grades would be included in a complete summation to 10.5. The Cape Photographic catalogue has 10427 stars in this zone of one degree, an average of 54 per square degree, for which the average of ninth magnitude stars is 7.5. Compared with the proportion of visual ninth, the photographic estimates should be one quarter magnitude brighter at this point, for this zone. The lowest photographic estimates are 11, in this zone, though in some portions the estimates extend only to 10. The larger number of stars in the photographic total is mainly due to the inclusion of a greater proportion of very faint stars in the Milky Way region. There is a wide range in the visual numbers of stars in the various hours of this zone, as will be found in any zone not parallel to the Milky Way throughout. The proportion rises from about two hundred, or 25 to a square degree, to nearly seven hundred, or 87 to a square degree in the densest regions. The zone $-57°$ is nearly parallel to the trend of the Milky Way in one part, in place of cutting across two opposite branches, as the zones farther north may be described as doing. In round numbers, the visual average is about five hundred stars for twelve consecutive hours, and half that number for the remaining twelve. The photographic enumeration shows still wider variation, from a hundred stars up to sixteen hundred per hour. Thus the relative proportion, for different hours of right ascension, has remarkably large variation. The explanation may be found in the two methods of enumeration. The visual work was designed to be complete to the tenth magnitude, and enough faint stars were observed to ensure this aim. In the sparsely populated regions, fainter stars were observed to fill in gaps, while in dense regions it was difficult often to observe all the essential stars. The Milky way was observed, in the earlier portion of the work, in zones of thirty or forty minutes width, in place of a full degree. In measuring the photographic plates, however, there is no more difficulty in enumerating the stars of the denser region, than is encountered in the others; it is only a matter of the employment of more time. The question may arise as to the limit of faintness of the images to be included, and this limit, as well as the quality of different exposures, will naturally give some variation to the catalogue in different parts of the scheme. The thickest region of the photographic list, in 10^h of $-57°$, has 200 stars to a square degree. Observing visually, there would be nearly thirty of such stars transiting each minute of time, in the full degree of width. The relative proportion of the two catalogues is illustrated in the figures of Table IV, which gives the respective numbers of stars for four different hours in $-57°$, the last hour of the table being in the Milky Way. The stars enumerated are also the basis of the more detailed discussion, in the tables that follow.

TABLE IV $-57°$

0^h		Visual	212	Photographic	231	Percentage	0.92
4		"	252	"	114	"	2.22
20		"	326	"	179	"	1.82
	Sum	"	730	"	524	"	1.51
10	"	"	695	"	1618	"	0.43

In order to test the visual scale, under the contrasted conditions of the above tabulation, the percentages are summed up in Table V, below. The Milky Way includes the count of 10^h R. A., while three hours are summed up in the region outside.

TABLE V $-57°$.

	Milky Way	Outside
To 7.0	0.006	0.008
8.0	.028	.024
9.0	.148	.094
10	.60	.39
11	.99	.88
12	1.00	1.00

The ratios of the summations of the successive grades up to tenth magnitude indicate that there has been but slight change of scale. But while 60 per cent of stars tabulated in the Milky Way region were estimated as bright as 10, the percentage of ten outside is only two-thirds as large, as greater numbers of the fainter stars were observed in the barren regions. Only one per cent were listed in the Milky Way as fainter than 11, while in the region outside there were twelve per cent of such faint estimates. The summation of stars to the ninth magnitude visual rises from 3 to the square degree, to 13, in the contrasted areas. The summation to ninth magnitude photographic rises from 4 to 20 per square degree.

Thus far, the visual magnitude scale has been tested on the basis of the assumed law of the distribution of the stars. The two tables following contain the direct comparison of the magnitudes of all stars common to both catalogues: first for the area in the three hours outside the Milky Way in $-57°$, and then for 10^h, which is the densest part of the sky in $-57°$ declination. The separate counts and summations are given for the brighter stars, for the next two units of grade, for each tenth from 9 to 10, and for the following grades as catalogued. The difference, V$-$P, when plus, signifies that the visual estimates are fainter.

TABLE VI −57°.

Mag.	Vis.	Σ	V−P	Photog.	Σ	V−P	Mean V−P
To 7.0	6		−0.35	3		−0.07	−0.21
7.1 to 7.9	10	16	−0.10	12	15	−0.03	−0.06
8.0 to 8.9	54	70	−0.06	60	75	0.00	−0.03
9.0	4	74	+0.17	26	101	+0.21	+0.19
9.1	7	81	+0.09	3	104	+0.10	+0.09
9.2	11	92	+0.09	44	148	+0.30	+0.20
9.3	21	113	+0.15	21	169	+0.34	+0.24
9.4	16	129	+0.13	42	211	+0.30	+0.22
9.5	20	149	+0.23	2 (dup.)		—	—
9.6	27	176	+0 24	52	265	+0.43	+0.34
9.7	35	211	+0.25	64	329	+0.60	+0.43
9.8	26	237	+0.29	20	349	+0.38	+0.33
9.9	21	258	+0.30	18	367	+0.71	+0.50
10	47	305	+0.29	45	412	+0.29	+0.29
10.2				41	453	+0.39	
10¼	58	363	+0.37				
10.4	—			37	490	+0.31	
10½	108	471	+0.65	0			+0.5
10.6	—			7	497	+0.36	
10¾	102	573	+0.88				
11	121	694	+1.00	27	524	+0.08	+0.5
11¼	36	730	+1.12				
11½	54	784	+1.44				
11¾	6	790					
			V−P			V−P	V−P
Means 9 to 10			+0.20			+0.36	0.28

TABLE VII. MILKY WAY.

Mag.	Vis.	Σ	V−P	Photog.	Σ	V−P	Mean V−P
To 7.0	4		−0.47	3		−0.40	−0.44
7.1 to 7.9	16	20	−0.14	10	13	−0.03	−0.09
8.0 to 8.9	70	90	+0.02	113	126	+0.26	+0.14
9.0	14	104	+0.39	37	163	+0.41	+0.40
9.1	10	114	+0.11	19	182	+0.39	+0.25
9.2	10	124	+0.36	66	248	+0.36	+0.36
9.3	22	146	+0.27	0	—	—	—
9.4	18	164	+0.33	87	335	+0.33	+0.33
9.5	40	204	+0.25	40	375	+0.34	+0.30
9.6	33	237	+0.29	158	533	+0.52	+0.40
9.7	42	279	+0.24	14	547	+0.57	+0.40
9.8	49	328	+0.33	174	721	+0.57	+0.45
9.9	18	346	+0.44	36	757	+0.52	+0.48
10	78	424	+0.38	310	1067	+0.50	+0.44
10.1				179	1246	+0.29	
10.2				106	1352	+0.32	
10¼	67	491	+0.52				+0.4
10.4				144	1496	+0.21	
10.5	116	607	+0.64	122	1618	+0.09	+0.4
10¾	43	650	+0.85				
11	35	685	+1.09				
11¼	8	693	+1.56				
11½	1	694	+1.9				
12	1	695	+2.2				
			V−P			V−P	V−P
Means 9 to 10:			+0.31			+0.45	+0.38

In deriving the value V−P, the visual magnitudes have first been taken as standard, and, on the same line the photographic magnitudes have then been taken as standard. The two values include the same stars only when the original estimates were the same. Thus 9.0 visual will combine stars brighter and fainter than 9.0 photographic. But when we reach the lowest estimate of either catalogue, as for instance the 11 photographic, the faintest grades of the visual can only combine photographic estimates that were equal and brighter, and the difference V−P is no longer balanced properly. If both catalogues had the same limit in the estimates, the sign of V−P would necessarily be reversed in the two combinations, at the limiting grade. As long as both combinations have a fairly representative number of estimates, the mean of the two differences of magnitude gives a consistent comparison of the two scales. This mean is given in the last column of the two tables, without regard to the exact number of comparisons in each combination. This system helps to eliminate the effect of the predilection for certain grades, which will be quite evident in the photographic enumeration. The reduction of the plate measures tends evidently in general towards even tenths, of which the lack of 9.1 and 9.5 in Table VI are illustrations, as well as the omission of the odd tenths from 10 to 11. All of the odd tenths from 9 to 10 of Table VII show the same tendency.

The variation in V−P is such as would be expected from the probable errors of estimates. The photographic estimates are fainter for the brightest grades. Magnitudes of stars above seventh were taken from the Cordoba Uranometry, for the visual catalogue, though estimates of brightness were made in the observing of the Durchmusterung, as checks. Below ninth magnitude the photographic estimates are brighter, increasing from 0.1 to 0.5 in the region outside the Milky Way, and standing more uniformly at 0.4 in the Milky Way region. Except for this slight variation of the respective differences, the comparison shows that the two scales preserve the same relation to each other in the Milky Way, and outside. This is contrary to the results of the discussion of the first two Cordoba volumes, where the visual was a quarter magnitude brighter outside the Milky Way, and a quarter magnitude fainter in at least one branch crossed by the zone. Much discussion has been given to the possible effect of the variation of galactic latitude upon the scale of magnitudes. But I believe it is possible for the visual observer to preserve the same scale, against the brighter background of sky, with sufficient experience in estimating visual magnitudes.

The stars up to ninth magnitude have many of them been observed in the Zone Catalogue, the magnitudes of which are the basis of the photographic scale. Few stars below ninth are probably recorded outside the Durchmusterung. The visual limit of estimates was 11½ in two of the hours compared, outside the Milky Way, and 11¾ in the third hour. The photographic limit was 11.0 in one hour, and 10.0 in the other two. The limiting grades, in the Milky Way, are indicated in Table VII.

One effect of the approach to the limit of one of the scales used in the comparison is that the average of the visual grades below 10 seems to fall nearly uniformly at 10.0 photographic, which should be 10.3 visual, in Table VI. Similarly the average of the grades below 10 visual of Table VII falls at 9.8 photographic, which should be 10.3 visual, also. These faint grades in the combination of the visual standards would appear to be of nearly the same brightness, judging by the photographic estimates.

In the summations at the various grades, the numbers of stars include all those observed in each authority; but the mean difference V−P is based upon those stars only that were observed in both catalogues, Some faint stars were omitted in each list.

Outside the Milky Way the visual omits 46 stars of the photographic in the three hours compared. Of these stars six are brighter than 10 P; one of 9.3, and the remainder 9.7 to 9.9. The photographic omits 312 stars of the visual, of which four are brighter than 10 V; one of 9.3, and the others 9.7 and 9.9. Each catalogue would appear to lack but one star, in these three hours, within the designed limits, 10 visual, and 9¼ photographic.

Within the Milky Way hour compared, the conditions of visual observation are more noticeable in their effect. The visual omits six stars brighter than 9.0 P, but five of these are in the cluster Lac. 4375, which was evidently too dense for the record of all the stars. In the Argentine General Catalogue the clusters are printed separately, at the end of the volume. This one is represented there, by 27 stars to 9¾, in less than six minutes of right ascension and nine minutes of declination. In the meridian circle observations of the clusters I had a share, and the magnitudes of all the clusters were revised by Dr. Thome and myself, with the twelve-inch telescope. In the field of this instrument the numerous stars can be identified and graded rapidly, and on a uniform visual scale, which may however differ slightly from the meridian circle scale, and from the scale we are considering here. The Durchmusterung estimates in this crowded cluster are much fainter than the estimates of the General Catalogue. In the earlier volumes, clusters

had usually been given special revision, in narrow zones. But they were difficult subjects.

The large clusters of the southern sky were photographed under Dr. Gould's direction, in the early years of the Cordoba Observatory, and the differential positions of the stars were printed in a special volume, in 1897. This cluster appears there with 582 stars to the magnitude $10\frac{3}{4}$, in the area from $10^h\ 25^m.8$ to $10^h\ 36^m.7$, and between declination $-56°.9$ and $-58°.3$, though but few stars are listed near the extreme limits. The dense part of the cluster contains 135 stars in ten minutes of declination, or 100 stars within the R. A. limits of the General Catalogue. The count of the visual Durchmusterung gives 30 stars in ten minutes of declination, within the R. A. limits of the General Catalogue, while the photographic has 72 stars. The photographic has 50 stars brighter than 10, while the visual has 17 stars brighter than its 10. This small area of the visual Durchmusterung would need revision, to make it complete on its own scale. In this whole hour the visual also omits 184 stars from 9.1 to 9.9 P, and 741 stars from 10 to 10.5 P. The greater number of the brighter stars omitted are within the cluster described above. There are in all 32 stars omitted brighter than 9.6 P, which corresponds in the tabulated differences to 10 visual.

The photographic omits only eight stars of the visual, in the Milky Way hour, one of 9.6 V being the only one brighter than 10 V. The photographic enumeration is evidently complete to its own limit, $9\frac{1}{4}$, in this region.

The separate scales can each be tested, in the two preceding tables, by the summation at the various grades. In table VI, adopting the summation at 9.0, and computing by Table I the summations at the grades between 8 and 10, the average of observed minus visual computed numbers would be ± 6 for the visual, and ± 30 for the photographic. The limit of the visual would be 10.7 of its own scale, and that of the photographic would be 10.2 of its scale.

In Table VII the visual scale checks up closely from 8 to 10, with an average difference between observed and computed of ± 8. Its limit would be 10.4 of its own scale. The photographic scale shows a change at 9.5, the difference between observed and computed summations being ± 22 above that point and nearly $+200$ below. Its limit would be equivalent to the summation to 10.3 of its scale.

Using the summations at the individual grades from 9 to $10\frac{1}{2}$, the relative magnitude scales of the two catalogues can be tested, as in the two following tables in which the computed differences of magnitude, based upon the ratios of the numbers of stars, are compared with the observed differences of magnitude, from Tables VI and VII.

TABLE VIII −57°

Mag.	Ratio	Comp. Δ	Obs. Δ
9.0	1.37	0.2	0.2
9.1	1.29	0.2	0.1
9.2	1.61	0.3	0.2
9.3	1.50	0.3	0.2
9.4	1.64	0.4	0.2
9.5	(1.43)	(0.2)	—
9.6	1.51	0.3	0.3
9.7	1.56	0.3	0.4
9.8	1.47	0.3	0.3
9.9	1.42	0.3	0.5
10	1.35	0.2	0.3
10¼	1.27	0.2	0.3
10½	(1.04)	(0.0)	(0.5)
Means		0.3	0.3

TABLE IX MILKY WAY.

Ratio	Comp. Δ	Obs. Δ
1.57	0.3	0.4
1.60	0.3	0.2
2.00	0.5	0.4
(1.70)	(0.4)	—
2.04	0.5	0.3
1.84	0.4	0.3
2.25	0.6	0.4
1.96	0.5	0.4
2.20	0.6	0.4
2.19	0.6	0.5
2.52	0.7	0.4
2.75	0.7	0.4
2.67	0.7	0.4
	0.5	0.4

Outside the Milky Way the agreement between the computed and observed differences of magnitude is good, up to 10¼. The photographic summations appear to have rather an excessive number of stars from 9½ down to its limit of 10½, in the Milky Way.

Adopting the observed differences of magnitude in the preceding tables, the scales may be tested by their respective summations, as in the two following tables.

TABLE X −57°

9.0 P = 101	9.3 V = 113
9.1 P = 104	9.4 V = 129
9.2 P = 148	9.5 V = 149
9.3 P = 169	9.6 V = 176
9.4 P = 211	9.7 V = 211
9.5 P = 213	9.8 V = 237
9.6 P = 265	9.9 V = 258
9.7 P = 329	10 V = 305
9.8 P = 349	
9.9 P = 367	
	10¼ V = 363
10 P = 412	

TABLE XI MILKY WAY

9.0 P = 163	9.4 V = 164
9.1 P = 182	9.5 V = 204
9.2 P = 248	9.6 V = 237
9.3 P = 248	9.7 V = 279
9.4 P = 335	9.8 V = 328
9.5 P = 375	9.9 V = 346
9.6 P = 533	10 V = 424
9.7 P = 547	
9.8 P = 721	
9.9 P = 757	
	10¼ V = 491
10 P = 1067	
	10½ V = 607

In Table X the agreement is good at 9.2, 9.4, and 9.6 P as confirmation of the difference of scales, as is also the lowest grade tabulated here.

In Table XI the grades 9.0, 9.2, and 9.4 give good confirmation of the difference of scales, but the summations of the photographic scale change at 9.5, and the visual enumeration falls off, relatively, beyond that point. But the latter can be seen to be nearly complete to tenth magnitude of its own scale, under the difficult conditions of making a full enumeration in the crowded regions of the Milky Way. The predilection for even tenths of the photographic scale is evident in these two tables.

The tests by counts, and the direct comparison of magnitudes of the two schemes of taking a census of the sky show that each catalogue

must be nearly consistent in the important part of the enumeration, which we may consider as the range of magnitudes from ninth to tenth. The brighter stars will have mostly been observed in meridian circle work. The stars between nine and ten are often required for differential measures of position, and the Durchmusterung will serve for the selection of the desired reference stars. It will also be the basis of a scheme of zone work, such as the Gesellschaft Northern Zones, designed to be inclusive to a definite limit of magnitude. The summation of the stars already observed in this last mentioned scheme, 6.4 stars to the square degree, shows that the equivalent of stars to the 9.2 of Argelander has been reached. The exact visual magnitude of any star near the limit of good observation with the meridian circle is a matter of importance, in this connection.

Lick Observatory,
Dec. 26, 1916,

THE DAYLIGHT MOON.

Like tiny cloud amid a fair, clear sky,
A quarter-moon sinks slowly to the west
As step by step the sun mounts from the east
In all the glory of a perfect day;
A week ago this moon resplendent shone
Full-faced, and gleaming like celestial pearl,
The grandest gem within night's darkened dome,
Its silv'ry light transforming vale and hill;
Now, faint and small amid the fair, clear sky
It still reflects some splendor from the sun—
No longer hidden—and of orbs of night
It shines alone amid days firmament.
Lit by the brilliance of Sol's blazing torch,
Yon quarter-moon sinks slowly to the west.

CHARLES NEVERS HOLMES.

Newton, Mass. 41 Arlington St.

TWENTIETH MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY.

[*Continued from page 318.*]

TWO NEW VARIABLE STARS IN ORION.

By Jacob Kunz and Joel Stebbins.

The spectroscopic binary η *Orionis* is found to be an eclipsing variable with a range of at least 0.15 magnitude at primary minimum, of 0.02 or 0.03 magnitude at secondary minimum, and with continuous variation throughout the period. The eclipses last probably less than half a day, and seem to occur slightly before the predicted times. The period is 7.9896 solar days, or 8.0115 sidereal days; and because of the slow change of phase the present season is unusually favorable for the study of this star.

Another new variable is π^5 *Orionis*, with a period of 3.70 days, and a range of about 0.05 magnitude. The character of the variation is not definitely established, but there is probably a continuous change of light due to the ellipsoidal figure of the bodies in a close binary system.

PARALLAX OF THE RING NEBULA IN LYRA.

By Burt L. Newkirk.

This is a report of progress in the study of the parallax of the central star of the Ring Nebula in Lyra based upon measures of 90 plates made with the Crossley reflector of the Lick Observatory. Most of these plates were made by Dr. H. D. Curtis and these are of exceptional quality. The plates fall into nine groups dated as follows:

October	1906	11	plates	May-June	1913	9	plates
April	1907	6	"	June	1915	14	"
September	1910	8	"	May	1916	10	"
May	1911	7	"	September	1916	11	"
July	1911	14	"				

Nine comparison stars were used. They are of about the same magnitude as the central star and situated so that the centroid of their images falls near the central star.

Measures were made in the X coördinate, the positive X coördinate being in the direction of increasing right ascension. The origin was taken at the centroid of the images of the comparison stars.

Measures of the first two groups when reduced in the usual manner indicated a negative parallax of about one-tenth of a second. This was reported at the Minneapolis meeting of the American Association for the Advancement of Science and the suggestion was made that this might be the effect of dispersion. In July 1911 Dr. Curtis made a series of plates to test this point. Measures of these plates confirm the dispersion theory and yield coefficients that were used in correcting the measures of all of the plates for dispersion.* Excepting the 1906, 1907, and July 1911 groups, the plates were all taken within half an hour of the meridian and for these the maximum correction for dispersion is 0″.027.

The means of the measures after application of correction for dispersion are as follows:

Date	No. Plates	X Coördinates of Nebula expressed in seconds of arc
October 1906	11	−39.88
April 1907	6	.83
September 1910	8	.89
May 1911	7	.88
July 1911	14	.87
May-June 1913	9	.81
June 1915	14	.83
May 1916	10	.81
September 1916	11	−39.83

The probable errors of these mean values of the coördinate of the central star are about 0″.01. The figures show at a glance differences much larger than the probable errors, which are not due to parallax or proper motion. The observations admit of two interpretations. First the relative parallax and proper motion in right ascension are sensibly zero and some condition affecting the measured coördinate has changed since 1911. This does not explain the discordance of the April 1907 group. Second it may be assumed that the coördinate should be about −39″.88 in the fall and −39″.83 in the spring, with no proper motion. This would give a parallax of about +0″.03. The values for May 1911 and September 1916 are not in accord with this interpretation. These being very good plates and the 1916 series an especially strong one, I am inclined to accept the interpretation stated first.

A least square solution of the whole series of plates has not yet been made. It will of course obscure the features noted above and yield compromise values of the parallax and proper motion with a small probable error.

* For information regarding this correction see note following this abstract.

At the outset of this investigation it was planned to take the plates in groups at the epochs of maximum parallax displacement, apply a correction for proper motion otherwise determined, and obtain the parallax by simple subtraction of the corrected means of the coördinate of the central star. By this means it was thought possible discrepancies such as have in fact appeared might be brought to light, whereas these escape notice and perhaps yield an erroneous parallax when a small number of plates are treated by the method of least squares.

Note on the correction for dispersion.

The equations of condition are obtained as follows:

Let $\Delta\mu$ represent the difference between the refraction coefficient for the nebula star and that for the comparison stars, and z the zenith distance of the nebula star, which is assumed to be at the origin of coördinates. Then dispersion causes a relative displacement of the nebula star toward the zenith, of an amount

$$\Delta\mu \tan z.$$

The consequent change in the X coördinate of the nebula star is

$$\Delta x = \Delta\mu \tan z \cos\theta = \Delta\mu X,$$

where θ is the angle between the X axis and the line joining the center of the plate with the projection of the zenith on the plane of the plate; and X represents the X coördinate on this projection of the zenith on the plane of the plate. X is expressed in units of radius.

Values of $\Delta\mu$ were found from the fourteen plates of the 1911 July group as follows:

$$\Delta\mu_1 = +\,0''.026 \pm 0''.0015 \text{ for 8 Seed 23 plates}$$
$$\Delta\mu_2 = +\,0''.028 \pm 0''.0025 \text{ for 6 Seed 27 plates}$$

This indicates that the effective wave-length of the light of the central star is shorter than that of the comparison stars by about 250 tenth-meters, which is a conservative value in view of results obtained by Burns (*L. O. Bulletin* **193**, 92).

NOTE ON THE ELLIPTICAL FORM OF MESSIER 13.

By Francis G. Pease and Harlow Shapley.

Photographs of globular clusters with the 60-inch reflector at Mount Wilson afford extensive material for the study of the distribution of stars in these systems. An elliptical arrangement has been found for the stars in the Hercules cluster, Messier 13. The existence of an axis or plane of symmetry is not evident among the brightest thousand stars, but for those fainter than magnitude 15 the ellipticity is found to be more or less independent of exposure time, magnitude interval, and

distance from the center. A more detailed discussion of the investigation may be found in the *Proceedings of the National Academy of Sciences.* Vol. 3, 96, 1917.

THE 72-INCH CANADIAN TELESCOPE AND ITS DOME.

By J. S. Plaskett.

The present condition of the optical parts, mounting, and dome of this installation were described and illustrated and are briefly as follows. The dome was shipped from Cleveland at the end of March 1916, arrived at Victoria about the middle of April, and erection of the structural work and mechanism was completed by July 1. The double sheet metal covering was completed about the end of September and the whole dome and mechanism are now ready for operation and perform very satisfactorily. The mounting of the telescope, which was temporarily erected at Cleveland in May and all the necessary fitting made at that time, was shipped about the end of July, arriving in Victoria on August 15. The work of hauling the heavy parts to the site, the polar axis weighing nearly ten tons and two other pieces seven, was successfully completed in about two weeks and erection started on September 5. By September 15 all the main parts of the instrument were erected and assembled but the elaborate permanent electric wiring and connections delayed the final completion of erection until about October 15. The whole mounting and the mechanical parts of the dome were by that time satisfactorily completed and in practical adjustment ready for operation. The short time required to get this tremendous machine erected and adjusted is an indication of the care used by the Warner & Swasey Co., in its design, construction, and fitting, reflects great credit on them, and I believe breaks all records in this regard. The whole mechanism operates to perfection and the design has been so carefully and ingeniously worked out both in telescope and dome that every necessary movement and operation can be performed with the greatest convenience and ease and in the minimum of time.

The 73-inch mirror is approaching the final stages of parabolization but the weather conditions during the winter prevent effective work and it is not likely to be completed until spring. As the mounting is all ready for its insertion, the telescope will probably be ready to begin work early in the summer of 1917.

SYSTEMATIC MOTIONS OF THE STARS.

By H. Raymond.

The paper is a summary of an investigation of the motions of the stars in the P. G. C. of Boss, by a method which in effect consists in finding the three momental axes of the velocity-figure. These axes are the directions in which the mean square components of motion are respectively a maximum, a minimax, and a minimum.

The direction of the maximum, i.e., the vertex of preferential motion, with the values of the mean square motion for the three directions, is shown in the table. The directions of least motion lie near the galactic pole.

Group	No. Stars	Vertex R. A.	Vertex Decl.	Mean Square Motions Max.	Minimax	Min.
		°	°			
Type B	492	100.6	−38.4	4.58	1.94	1.33
A	1647	92.4	+ 1.8	25.65	9.15	2.57
F	656	93.1	+ 2.1	58.05	28.78	22.66
G	446	93.8	+ 3.4	32.26	15.81	9.96
K	1227	93.1	+11.3	29.30	18.71	11.46
M	223	94.0	+25.3	28.14	12.58	3.48
"X"	693	83.9	+30.2	21.08	12.72	5.33
P. M. <20″	5384	91.9	+ 4.2	28.91	14.99	9.89
P. M. 20″-80″	559	92.5	+35.3	745.6	261.4	194.7
P. M. <80″	5943	92.3	+16.9	107.3	58.7	31.8

"X" includes stars of N and O types and those too faint to be found in the Draper Catalogue. The vertices by type fall into two groups, A to G and K to X. B is discordant.

The solar motion by the method of Bravais was obtained at the same time. The results agree closely with those obtained from the same material by Airy's method (L. Boss, *A. J.* 614, 623-4) and Schwarzschild's method (*A. J.* 676).

THE SOUTH POLAR ECLIPSE OF 1917 DECEMBER 13.

By William F. Rigge.

This annular solar eclipse is exceptional in that its central line lies exactly across the south pole, if the latter has an elevation of 9107 feet above sea level; also in that its various phases are visible in all longitudes and at all local times. A series of nine views showed the general feature of the eclipse, the maps giving the times for the beginning, middle and end, the magnitude, the position angles of the points of first and last contact with reference to the Sun's vertex as well as to its north point, the central line, and the so-called negative shadow near the south pole in plan and elevation.

STELLAR IMAGES ON A PHOTOGRAPHIC PLATE AS AFFECTED BY DEVELOPMENT. *

By F. E. Ross.

This is a report on a preliminary investigation of a two-fold nature: (a) determination of differences in power, if any, of various developers in developing faint stellar images; (b) determination of differences in quality, if any, of stellar images, depending upon the developer, with special reference to the accuracy of measurement of their distances apart on the plate.

The tests were made by photographing a series of small round holes in a plate. Under (a) above, no certain differences were detected. In investigating (b), pyro and caustic hydrochinon (Process developer) were tried, and development carried to 2 and 4 minutes. From the measurement of three hundred and twenty distances between images it was established that greater accuracy in measurement was secured where the Process developer was used, and for the shorter development time. This result was anticipated, since the appearance of the images was decidedly better for short development in Process developer than for any other of those tried.

THE MINIMUM RADIATION VISUALLY PERCEPTIBLE.

By Henry Norris Russell.

This communication supplements the recent work of Ives, (*Astrophysical Journal*, **44**, 124, 1916) by the introduction of more precise values for certain data which were inaccessible to him. Taking the diameter of the pupil of the eye, in darkness, as 8.5 mm according to Stevenson, and the faintest object visible on a dark background as equivalent to a star of magnitude 8.5, according to observations by H. D. Curtis and by the writer, the minimum energy perceptible by the eye comes out 7.7×10^{-10} ergs per second, which is equivalent to one small calorie in 1700 million years. (See *Astrophysical Journal* **45**, 60, 1917.)

ORBITS OF KRUEGER 60 AND EPSILON EQUULEI.

By Henry Norris Russell.

Recent observations of these two interesting binary systems, generously communicated to the writer by Professor Barnard and Professor

* *Communication of the Research Laboratory of the Eastman Kodak Company. No. 47*

Aitken, make it possible to secure good preliminary orbits. In the first case two alternative orbits are given, representing approximately the range of uncertainty still existing. In the second, the probable errors of the elements were derived by a least square solution.

The resulting elements are as follows:

	Krueger 60		ε Equulei
	I	II	
Period	46.0 yrs.	54.9 yrs.	97.4 ± 5.0 yrs.
a	2″.49	2″.86	0″.61 ± 0″.04
e	0.357	0.182	0.72 ± 0.09
Apastron	1902.6	1902.1	1873.5 ± 0.22
γ	25°.1	39°.6	85°.5 ± 0°.3
Ω	102°.8	113°.6	106°.8 ± 0°.2
λ	153°.8	161°.0	0°.0
	Angles decreasing		Angles decreasing

With the parallax 0″.256 for the first of these systems, the combined mass of the components comes out as 0.44 times the Sun's mass from orbit I and 0.47 from orbit II. The ratio of the masses of the components is still liable to some uncertainty, but it seems clear that the brighter component is more massive than the other, and probably twice as massive. The mass of the fainter component is therefore probably not more than one-sixth of that of the Sun,—which is smaller than any other mass of a visible star which has so far been reliably determined.

The possibility of getting a good orbit in the first case depends on the wide separation, and the number and high precision of Barnard's measures. The observed arc is 115°. For the second star the whole motion in angle is only 25° and the orbit depends entirely upon the dynamical relations between the distances and the time. With the aid of Aitken's recent measures, when the separation was less than 0″.10, a definite solution was reached. This star will be very close for some years to come.

The measures of the next ten or fifteen years will place both these systems in the list of those with very accurately known orbits.

THE ERRORS OF THE SUM OF A NUMBER OF TABULAR QUANTITIES.

By Frank Schlesinger.

This paper deals with the errors that are to be expected in the sum of a number of tabular quantities. Frequency laws for the errors are derived in the three cases of direct tabular quantities, interpolated tabular quantities with the retention of an additional decimal, and interpolated quantities rounded off to the last tabular place. It is shown that in each case, when the number of items in each sum is large the frequency laws approach the exponential form. The slowness with which these errors accumulate is remarkable.

PHOTOGRAPHIC MAGNITUDES IN THE SELECTED AREAS OF KAPTEYN.

By Frederick H. Seares.

Photographic magnitudes of all stars registered with an exposure of 15^m are being determined with the 60-inch reflector for small fields in each of the Selected Areas, on and north of the equator. Relative magnitudes are available for 75 areas and the number of stars to the limiting magnitude of the photographs is known for 13 additional areas. The total for the 88 regions is about 40000 stars, which is sufficient for a preliminary study of the variation of star-density with galactic latitude.

A comparison with the Greenwich results by Chapman and Melotte reveals a large divergence; at the galactic pole the densities from the two investigations are the same, but in the Milky Way the Mount Wilson counts give more than five times as many stars as those by Chapman and Melotte.

The limiting magnitude of the Mount Wilson photographs is approximately 17.5. Comparing Mount Wilson densities with those of Kapteyn for 16.3, which is the Groningen visual magnitude corresponding to the Mount Wilson limit, it is found that the agreement is excellent. The small systematic divergence is of the order that might be expected from the uncertainty of the data compared. The galactic condensation from the Mount Wilson counts is 21.4, which includes all stars to the limiting magnitude of the photographs.

(See *Proceedings of the National Academy of Sciences*, **3**, 188, 1917.)

NOTES ON STELLAR CLUSTERS.

By Harlow Shapley.

The continuation of the study of magnitudes and colors in clusters has yielded a number of interesting results, of which the following are the most significant.

1. In Messier 13 the colors of the stars between photovisual magnitudes 15 and 17 have been checked with a new series of plates and the strong preference for negative color-indices is verified.

2. All the non-cluster stars near Messier 13 appear to belong to the redder color classes.

3. A catalogue of magnitudes and colors for the open cluster Messier 11 has been completed. In most characteristics the cluster stars are not different from the stars in the surrounding galactic clouds. The frequency of color class is very much like that for the brightest stars in the neighborhood of the Sun.

4. All color classes are found among the faint stars in the galactic clouds. If, as is probable, the negative color-indices in these regions refer to B-type stars of average luminosity, the clouds must be at a distance much in excess of 10,000 light years.

5. Negative color-indices have also been found among faint stars in five other widely separated mid-galactic regions. The inference is that the color of the faint stars depends on galactic latitude, and that the extent of the Galaxy in all longitudes is several times greater than has been deduced from the study of variables and the analysis of the motions and luminosities of the brighter stars.

6. Accepting the presence of negative color-indices among the most distant stars as a criterion for the absence of absorption of light in space, the result previously found for Messier 13 may now be generalized. Negative color-indices have been found in ten different regions (mostly globular clusters) in both galactic hemispheres and with galactic latitude ranging from 0° to 77°. It appears fairly conclusive, therefore, that regardless of direction, selective light scattering is inappreciable, except perhaps in some peculiar local regions of the sky.

LIBRATIONS OF THE MOON ILLUSTRATED BY PHOTOGRAPHS.

By Frederick Slocum.

This paper was suggested by a request of the late Professor Ebert of Munich for photographs from which to study the topographic features of the Moon brought into view by its librations.

Lantern slides of photographs taken for him with the 40-inch refractor of the Yerkes Observatory were shown to illustrate the librations in latitude and in longitude and the varying inclination of the Moon's axis to the Earth's equator at the time of the full Moon, and photographs taken with the old 12-inch refractor of the Van Vleck Observatory were used to illustrate the librations at other phases.

The relation of libration to phase was discussed and tables giving the changes in libration during a month, and the changes in libration for a given phase through a year were shown.

CHRONOGRAPHIC DETERMINATION OF THE LAG BETWEEN THE ARLINGTON AND THE GREAT LAKES RADIO TIME SIGNALS.

By Frank D. Urie.

The transmitting clock at the U. S. Naval Observatory sends time signals by wire to Arlington, Radio, Va., and to Great Lakes, Illinois. At each of these naval radio stations the wire signals are automatically

converted into radio signals. Owing to the 800 miles of telegraph wire between Washington and Great Lakes involving several make-circuit relays, the Great Lakes time signals lag perceptibly over those from Arlington.

The determination of the time lag between Arlington and Great Lakes was undertaken by the writer in October 1916, at the request of Captain Hoogewerff, Superintendent of the Naval Observatory.

The apparatus used at the Radio Laboratory of the Elgin National Watch Company, Elgin, Illinois, for recording Arlington (700 miles) and Great Lakes (30 miles) was described at the 1915 meeting of the Society (see *Popular Astronomy* **23** 645, 1915).

The following table contains the data of the investigation:

1916	Number of recorded comparisons with Arlington	Great Lakes	Lag of Great Lakes
Oct. 30, Monday	37	22	+0.085 sec.
Nov. 17, Friday	26	87	+0.094
Nov. 20, Monday	22	42	+0.081
Nov. 29, Wednesday	64	92	+0.078
Dec. 5, Tuesday	18	10	+0.087
Dec. 6, Wednesday	60	49	+0.079
Dec. 8, Friday	58	15	+0.098
Dec. 9, Saturday	77	45	+0.080

The average of the above eight determinations gives the lag between Arlington and Great Lakes as $+ 0^s.085 \pm 0^s.002$.

THE PARALLAX OF THE PLANETARY NEBULA N.G.C. 7662

By A. van Maanen.

The small probable error and the apparent absence of large systematic errors in the Mount Wilson parallax work seemed to justify an attempt to determine the parallaxes of some of the nebulæ. The first field finished is that of N. G. C. 7662. This nebula has a sharp stellar nucleus as was shown on a slide. Sixteen plates with exposures from 25 to 35 minutes were taken during 1915 and 1916, all of which were of good quality for measuring. The eight comparison stars used were indicated on the slide.

The result gives for the relative parallax

$$\pi = +0''.021 \pm 0''.004$$
$$\mu_\alpha = -0''.003 \pm 0''.008$$

This proper motion agrees very well with that found by Dr. Curtis from the Lick plates, which he kindly communicated to me to be $- 0''.005$.

To derive the absolute parallax of the nebula we must add approximately 0″.002 to the value given above; the resulting parallax of + 0″.023 would place the nebula at a distance of about 140 light-years. As the angular diameter of the whole nebula is about 26″, its linear diameter seems to be of the order of nineteen times that of the orbit of Neptune. (See *Proceedings of the National Academy of Sciences*, **3**, 133, 1917.)

THE TRANSMISSION OF RADIATION BY THE EARTH'S ATMOSPHERE.

By Frank W. Very.

From the moment of their entrance into the Earth's atmosphere, the solar rays suffer depletions of various kinds. The extreme ultra-violet rays of wave-lengths shorter than 0.3 μ are completely eliminated in the rarer layers of the upper air, being used up, we may presume, in ionizing its ingredients. As a result of these activities, various absorbent substances are produced which obstruct the passage of groups of rays in this and in other parts of the spectrum. Some of the atmospheric absorbent constituents are nearly constant in amount, for example oxygen and carbon dioxide; others, such as water vapor, the hydrols and ozone, are exceedingly variable, and at the same time are powerful, absorbents. To this must be added that there is a scattering of the shorter waves by the air-molecules; and a more general reflection of all kinds of rays by still coarser atmospheric particles. The energy of the rays struck out by the absorption of gases and vapors remains in the air as heat, to be eventually lost as selective radiation to space in the extreme infra-red part of the spectrum; but the diffused and reflected rays are partly turned downwards to the Earth's surface and added to those directly transmitted rays of the Sun which have escaped depletion.

The return radiation from the Earth's surface behaves quite differently, since, if the air be clear, some of the rays pass out freely to space, but others are absorbed in a comparatively shallow layer of air next to the Earth's surface, and chiefly by aqueous vapor. Consider two elements of surface—a and b. The larger part of the telluric radiation from the element a is absorbed by the vaporous contents of the air within a hemisphere of radius x, greater than the distance ab; and within a vertical angle α, those rays in the direction of b communicate a portion of their energy to a part of the air column over b whose height is $h = x \sin \alpha$. But an exactly equal amount of the radiation emitted from b is absorbed by a height h of the air column over a, and thus all of the radiation emitted *obliquely* from any given element of surface (a) is compensated by radiation from points within the circle of radius x, and received by a's own vertical column. We may there-

fore treat this radiation as if it were an interchange between parallel and indefinitely extended, horizontal surfaces at known temperatures, and at a distance apart equal to x; that is, it is only necessary to consider a *vertical* interchange.

Examples of apparent transmissivities (T) for successive atmospheres (ϵ) are appended:

	$\epsilon =$	1	2	3	4	5
Solar radiation,	T_1 % =	75.0	81.0	84.8	87.6	89.6
Telluric radiatian,	T_2 % =	60.7	77.9	84.7	88.2	90.5

T_1 from observations by Savélief, surface pressure of aqueous vapor = 0.8mm
T_2 from observations by Very, surface pressure of aqueous vapor = 12.7

The actual transmission of the telluric rays was only 26.8% on the occasion cited, and the larger part of the absorption was produced by the first tenth of an atmosphere, or thereabouts. The apparent transmissivities are therefore assigned to a small remnant of sifted rays whose easy passage is due to the abstraction of the readily absorbed rays. These apparent transmissivities are never constant, even when derived from the best observations, and extrapolations based upon them always yield too large a value for the transmission at small air masses, and too small a value for the computed initial radiation, as in the telluric example cited. Here, however, the initial radiant values are accurately and independently known from observation and serve as a test of the method. The initial solar radiation, on the contrary, can not be directly observed; but from the test we may infer that similar extrapolation methods, applied to the solar observations, will yield a value of the solar constant which is too small, and this inference is fully supported by the high-level results obtained by the aid of the sounding balloon.

VELOCITY PLANES INDICATED BY THE APICES OF STELLAR MOTIONS.

By Albrecht von Flotow.

Among the 654 stars of Boss's Preliminary General Catalogue whose proper-motions exceed 0″.15, there are 130 stars with measured parallax and observed radial motion. Considering only those stars whose parallax is positive, the number is reduced to 116. Computing the individual apices of these stars, and charting them, two planes of preference are clearly indicated, one along the Galaxy, the other perpendicular to it. The second plane very nearly passes through the generally accepted apices of preferential motion. While the available data are admittedly meager, it seems desirable to establish criteria whereby any particular apex may be assigned a position in or outside the two planes of velocity.

Two conditions are obtained, the first taking into consideration errors in π and ρ, the second considering an error in the position of the assumed pole of the velocity plane. By subjecting the 116 stars to the two criteria it develops that 62 apices belong to the first plane, 57 to the second, and the remaining 27 to neither plane. Thirty apices are common to both planes. Omitting the latter the solution for the poles gives

1 plane	R.A. $= 192° \pm 4°$	Decl. $= +34° \pm 2°$
2 plane	R.A. $= 152° \pm 7°$	Decl. $= -46° \pm 4°$

Assuming the apices to lie in one of the two planes the absolute error of an observed parallax, affected by the errors of proper-motion, solar motion, and error in the computed apices is $0''.036$.

It is interesting to note in this connection that an arithmetical mean of the 54 negative parallaxes of the Yale publications gives the value $-0''.032$. The absolute error of an observed parallax must be in excess of this amount.

The detection of an apparent secondary plane of velocity distribution among the large proper-motion stars becomes more significant in view of B. Boss's detection of an apparently similar secondary plane of stellar distribution.

THE DRAPER QUARTZ SPECTROGRAPH OF THE LICK OBSERVATORY AND SOME OBSERVATIONS RECENTLY SECURED WITH IT.

By W. H. Wright.

The optical parts of the instrument, whose description forms the subject of this paper, are of quartz. It is designed for observation in the ultra-violet region of the spectrum ,to which ordinary glass is opaque, and is used in conjunction with the Crossley reflecting telescope.

The mounting is so arranged as to permit the use of the spectrograph either as a slit instrument of the conventional type, or as a dispersive agent, forming with the telescope a prismatic camera. For the present it is being used in the latter capacity for the observation of the spectra of the brighter planetary nebulae.

Photographed with this apparatus, numerous images of a nebula, as exhibited by its distinct radiations, are recorded on the plate, i. e., an image of the nebula is impressed by each line of the spectrum. These images are frequently not alike—for the same nebula—and a study of the irregularities is the principal purpose for which the instrument is at present being used.

In addition to furnishing material for this investigation the spectrograph has revealed a number of previously unobserved lines in the ultra-violet, the most extreme lying at λ 3313, and an apparently continuous spectrum terminating on its less refrangible edge at about λ 3652.

The instrument was constructed chiefly through a grant from the Draper fund of the National Academy of Sciences, but in part through expenditures by the Lick Observatory.

REPORT OF COMMITTEE

REPORT OF THE COMMITTEE ON ASTEROIDS.

By A. O. Leuschner, Chairman.

Your committee regrets to be unable to announce at this time whether "Bahnelemente und Oppositions-Ephemeriden der Kleinen Planeten" usually distributed by the Berlin Recheninstitut well in advance will be available by the beginning of 1917, or whether hereafter the ephemerides for the four brighter planets, the preparation of which has been discontinued in England, will be furnished by Berlin. As soon as definite information on these points is available it will be published in the Bulletin of the Harvard College Observatory. Your committee has held an informal meeting at Cambridge in November and has discussed plans of work for the future. Some of these plans require active intercourse with the Berlin Recheninstitut and must by necessity be held in abeyance for the present. Among the problems which press for consideration is the interpretation of the variability of some of the asteroids. Considerable data are available, particularly at the Harvard College Observatory. In this connection your committee has under consideration the advisability of suggesting experimental studies of the reflection and diffusion of light by rocky surfaces, possibly by means of aeroplanes.

It is hoped that at the next meeting of the Society we shall be able to submit a more definite report.

THE INFREQUENCY OF CONNECTION BETWEEN SOLAR PROMINENCES AND SPOTS AND FLOCCULI.

OLIVER J. LEE.

Probably no other class of objects observed in modern practical astronomy is of such absorbing interest in every way as the solar prominences. Their wonderful beauty and variety of forms, from the lace-like tracery of intermingling jets to the towering majesty of the giants of their kind; their erratic motions and changes of appearance, shooting out to enormous distances in a few moments of time, and disappearing while you watch, or slowly growing and lazily existing for week-long periods of time almost without change—all these and many more fascinating features will more than repay the time and study given to observing them. It is to be hoped that possessors of moderate sized telescopes in this and other countries will have them fitted out with modest spectroscopic equipment with the idea of recording, from visual observations, the positions, forms and changes of solar prominences.

The real study of prominences began in 1868, when the brilliant discovery was made by Lockyer and Janssen that prominences can be observed with a telescope and spectroscope on any clear day. As early as 1870, Young attempted to photograph the prominences, but was led to abandon it because of difficulties which he encountered in using the wet collodion film. The successful operation of the spectroheliograph by Hale and also by Deslandres in the early nineties soon placed the observation of prominences upon a permanent basis. Photographic records of prominences for the past 10 to 20 years are now available at various observatories in the world. These even now are an invaluable supplement to the older and longer series of visual observations maintained by European observers, notably those at Rome, Catania and Zurich.

Reference to that part of the descriptive literature of the Sun which concerns prominences, spots and faculæ reveals that we still hold to the ideas expressed by the observers of a generation ago in the matter of the relations of these phenomena to each other. The literature, up to the present, contains quotations such as: "spots being surrounded by rings of eruptions"; and, "In many cases, at least, faculæ when followed to the limb of the Sun, have been found to be surrounded by promi-

nences, and there is reason to suppose that the fact is a general one. The spots, on the other hand, when they reach the border of the Sun's image, are commonly surrounded by prominences more or less completely, but seldom overlaid by them." It is probable that the author of these statements had in mind at the time only the eruptive spikes and jets which it is true are found chiefly in the immediate vicinity of active spots and faculæ. The converse, which is explicitly affirmed in the above quotations, is certainly not attested by modern observations. If, however, the term eruptive prominences be made to include all small and large structures which spring up in a short time to change and dissipate within a few hours or a day, the observations at once indicate that a restatement needs to be made of their relations to spots and faculæ. It has generally been held that the so-called quiescent prominences are not related to spots and faculæ, since they occur in large numbers in the higher solar latitudes. I give a remark by Ricco:* "Les observations solaires que nous poursuivons depuis 30 à 40 ans nous ont convaincu qu'll n'y a pas de relation entre les protubérances (non eruptives) et les taches et facules. M. Wolfer est aussi de cet avis† et ses Cartes heliographiques le prouvent avec toute évidence." Spectroheliographic evidence proves this conclusively since prominences are observed in the polar regions of the Sun, where spots and flocculi never occur, which continue for days and weeks without much change and hence demonstrate their quiescent nature. Such prominences are found in nearly every solar latitude. What shall we say now of that large and important class of interesting prominences which can be classified neither as jets and spikes relating themselves more or less closely to spots and faculæ, not as quiescent prominences? These prominences are often very large and very active. They seem to occur in much larger regions of the Sun's surface than that occupied by the belts of spots and flocculi. They frequently appear on an unmarked field far from spots and flocculi, and again in areas which have a rough surface on a plate of the disk taken with the center of the H line of calcium. I can find no direct statement in the literature of the prominences which definitely includes these in the class with the jets and spikes of the eruptive type. Nor can they be said to belong to the quiescent type of prominences, except perhaps for the cases which appear for longer periods of time without material change and then suddenly become very active and disintegrate in a short time.

In a recent examination of 6,409 different prominences visible on plates taken with the Rumford spectroheliograph in the last thirteen

* *Comptes Rendus*, **155**, 496, 1912.

† *Publicationen der Sternwarte des Eidg. Polytechnicums zu Zurich*, Tome I et suiv.

years this gap in the classification of solar prominences has been very evident. For purposes of the physical study of the Sun, it is clear that a classification of prominences on the basis of their degree of activity is more significant than any other. It is possible that for practical purposes classes to the number of 4 or 5 would be better than a more detailed system based upon the presence or absence of certain metallic vapors in each prominence.

I have recently given an account* of an investigation to find out what percentage of the solar prominences occur in the immediate vicinity of spots and faculæ or their monochromatic appearances, flocculi. An examination was made of 5,519 solar plates taken with the H line of calcium between 23 March 1903 and 24 January 1917. As stated above, 6,409 different prominences were counted, of which 2,341 were found to lie between the parallels of 45° north and south solar latitude and the poles of the Sun. The remaining 4,068 prominences occured between these parallels of latitude, that is to say in a general way in the central belts of the solar surface to which spots and flocculi are limited. The prominences were also counted separately for epochs of greater and of less solar activity in order to detect any possible difference in the degree of connection with spots and flocculi depending upon the change in the general activity of the Sun. The point on the Sun from which each prominence was observed to have sprung up was examined on the plates of the disk to determine whether or not it had immediate connection with spots or flocculi. A diagram was designed for finding the point on the solar disk up to regions removed as much as 3 to 4 days from the edge of the disk, corresponding to the position angle of any prominence on the limb of the Sun.

Out of the 4,068 medial prominences observed in the time interval defined above, 2,867 occurred at the times of maximum solar activity and 1,201 near minimum activity. Only 166 out of 2,867, that is 5.8 per cent of the prominences seen in the period of maximum were directly connected with spots, and for the period of minimum 70 out of 1,201, or 5.8 per cent, were so connected. The percentages of the prominences connected with flocculi, in which no spot was visible on the day of observation, was 9.1 and 5.2 for the two periods respectively. The *infrequency* of connection therefore obtains to about the same degree, whether the general condition of the Sun is active or quiet. We have been in the habit of assuming that when spots or flocculi approach the limb there would be visible jets and prominences, without examining the foundation of this expectation. Jets do often appear under such conditions, but it is equally true that a great many highly

* *Astrophysical Journal*, **45**, 206, 1917.

eruptive prominences occur in unmarked regions of the solar surface. The data given above cover somewhat more than one complete cycle of solar activity. There is apparently no reason why this particular cycle should differ from any other in its evidence upon this question. Hence we must conclude that prominences taken as a whole do not have a marked tendency to appear in the immediate neighborhood of spots and flocculi.

Yerkes Observatory, May 1917.

PHOTOGRAPHIC MAGNITUDES OF STARS IN THE SELECTED AREAS OF KAPTEYN.*

FREDERICK H. SEARES.

A casual experience with the details of astronomical investigation reveals, in the number of the stars, a serious difficulty to be overcome in undertaking any discussion of the development and structure of the stellar universe. Telescopes of even moderate size bring before the observer stars to be counted by tens of millions, while those shown by instruments of the highest power are many times more numerous. Since the individual examination of all these objects will not be seriously considered, the question arises as to a rational limitation of the program of observations. Fortunately, the problem is not as hopeless as it seems, for very important and illuminating facts are to be derived from a minute percentage of the total number of stars seen in our telescopes, provided only that the objects chosen for study be representative of the collection as a whole.

Kapteyn, in 1906, showed that by proper restriction and selection we might hope to obtain, within a comparatively few years, a fairly comprehensive notion of the salient features of the structure of the universe. His well-known 'Plan of Selected Areas,' published in that year,† formulates in a definite way the investigations to be undertaken in order that we may acquire an adequate knowledge of stellar positions,

* From the Proceedings of the National Academy of Sciences Vol. 3, March, 1917.

† Published by the Astronomical Laboratory at Groningen.

distances, proper motions, radial velocities, spectra, and magnitudes, both visual and photographic, which are the data essential for a consideration of the questions of structure and development.

The principle of selection adopted by him involves the detailed examination of all objects within the reach of observation, situated in certain small areas uniformly distributed over the sky. About two hundred such Selected Areas are included in the list; the center in each case is definitely marked by a star of more than average brilliance, but the boundaries are elastic and may be adapted to the special requirements of any given problem. In order that the accidental irregularities of distribution may not too greatly influence the results, each region, in dealing with stars of moderate brightness, will cover one or two square degrees; but for the very numerous fainter objects, sufficiently comprehensive data can be obtained from much smaller areas, including, in some cases, only a small fraction of a degree.

Kapteyn thus avoids the task impossible of execution and sets one that is more appropriate to our limited capacities. We occupy ourselves with what in effect is a sampling of the contents of the heavens, and, because of that underlying regularity presupposed by all our science, accept with some confidence its inferences and deductions as to the totality of the universe of stars.

But with even this much restricted plan, the actual labor still is very great, beyond the resources of any single institution, and subdivision and coöperation have therefore been necessary. Various observatories and numerous individuals have devoted themselves to special programs of observation, with the result that data are now rapidly accumulating.

In accordance with this plan several investigations, for which the equipment of the Solar Observatory is peculiarly adapted, have been undertaken at Mount Wilson. One of these, with which this note is particularly concerned, relates to the determination of photographic magnitudes.

In any scheme of sidereal research, measurements of stellar brightness are an important element; for a knowledge of stellar distribution and of the concentration of stars toward the galactic plane, they are essential; for the statistical discussion of stellar distances, they furnish criteria of the greatest value; and when both photographic and visual (or photovisual) magnitudes are known, we have immediately available values of the color which, for the fainter stars at least, are of much importance, since they afford, for objects inaccessible to spectroscopic observations, a hint as to physical condition not to be obtained by any other means.

In every photometric research a precise knowledge of the scale of magnitudes is an essential feature, and for the Mount Wilson investiga-

tion this primarily was the requirement. Professor Kapteyn had previously been furnished with photographs of an hour's exposure, with the 60-inch reflector, on each of the Selected Areas on and north of the parallel at $-15°$ declination; and for the reduction of these photographs sequences of standard magnitudes were required. Although standards for the faint stars were especially desired, brighter objects have also been observed in order to facilitate comparisons with other photometric systems.

A simple means of deriving a sequence of standards is to transfer to the region in question, by means of intercomparison photographs, the standards already established at the Pole. But in the present case this method could not be used; the range of brightness to be covered was too great, and the limiting magnitude to be attained too faint.

Separate determinations of the scale were accordingly undertaken for each area, and, as a means of greater precision, these were based on all the stars shown on the photographs used. We have, therefore, for each region a large number of magnitudes, instead of merely sequences of standards. The labor was thereby somewhat increased, but, besides the greater accuracy, there is the advantage of a complete utilization of the data of observation.

To establish the photographic scale of magnitudes, the relation between the brightness of a star and the size of its photographic image must be found. This can be reliably accomplished by means of successive exposures, of constant duration, made on the same plate with light of different intensities.‡ The variations in intensity, which must be known, can be produced through a change in the effective aperture of the telescope by adding diaphragms or screens of wire gauze. Individual stars will therefore show two or more images, with differing dimensions corresponding to known differences of magnitude. When once the images on any photograph have been completely measured, a simple interpolation process quickly gives the relative magnitudes of all the stars. To determine their absolute values, a zero-point correction must be added, whose value has to be derived from other data.

If the scale is to be established over a considerable range of magnitude, photographs of both long and short exposure will be required; and to reduce the influence of the various errors, which in photometric work are always numerous and troublesome, several separate determinations will be made, preferably with diaphragms and screens which

‡ Seares, F. H., *Mt. Wilson Contrib.*, No. 80; *Astroph. J., Chicago*, **39**, 1914, (307-340).

change the intensity by different amounts. The program adopted for each of the Selected Areas is shown in the Table.

No. Plates	Aperture in inches	Duration of Exposures
1	60, 32, 32, 60	15^m
1	60, Screen, Screen, 60	15
2	60, 32, 14, 9, 9, 14, 32, 60	2

This arrangement of exposures admits of six separate determinations of the scale, and a possible maximum of sixteen different values of the magnitude of a given star, though the average number is only five or six; for the faintest stars there are naturally but two—those derived from the full-aperture images of the two plates of long exposure.

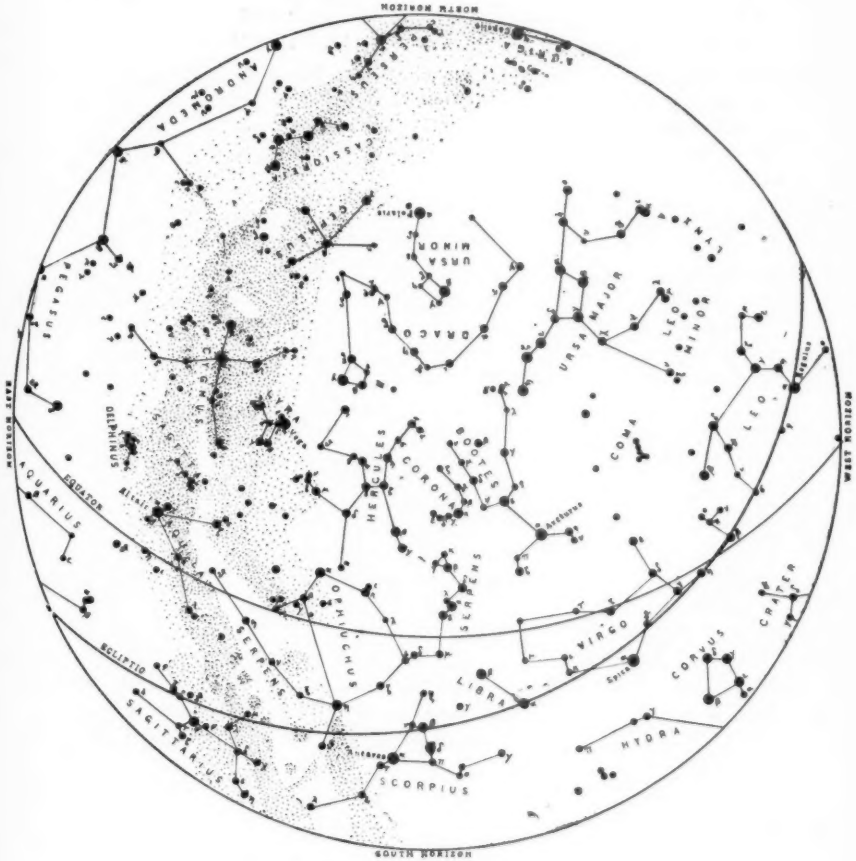
It was planned originally to include only the 115 Selected Areas on and north of the Equator, and the 460 plates necessary for the derivation of relative magnitudes in these regions have nearly all been taken. The measures are also well advanced, and for 80 regions the reductions up to and including the relative magnitudes, are complete. It now seems desirable to include the 24 areas at $-15°$, and these accordingly will be added to the program.

To reduce the relative magnitudes to absolute values on the international system, it is convenient to rely upon the North Polar Standards, for which precise results are known. To determine the various zero-point corrections, two series of intercomparison photographs have been made: first, comparisons of each area with the adjacent areas of the same zone of declination, and second, duplicate comparisons of six equidistant areas in each zone with the region of the Pole. By means of the zonal comparisons, the magnitudes of each zone can be brought to a common zero-point, which, through the polar comparisons, can finally be referred to the international standard. Since the intercomparison exposures are of only two minutes duration, the photographs are rapidly accumulated. All but 50 of the 302 plates required for the original program have been obtained.

Since these photographs have not yet been reduced, the lower limit for the magnitudes is not accurately known, but probably it is not far from 17.5 on the photographic scale. The range of brightness is always such as to include the central star of the area and usually is eight magnitudes or more. The field is that of good definition, with the full aperture of the 60-inch mirror; its diameter is 23′ and its area about one-ninth of a square degree. The number of stars shown in such a field on the plates of fifteen minutes exposure varies from 40 or 50 in high galactic latitudes to 2000 or 3000 in the star clouds of the Milky Way. The total for the areas on and north of the Equator should be 55,000 or 60,000.

PLANET NOTES FOR JULY AND AUGUST, 1917.

During the months of July and August the sun will move south and east from the constellation Gemini through Cancer, into Leo. During the two months its



THE CONSTELLATIONS AT 9:00 P. M. JULY 1.

declination will change from +23° 8′ 28″ to +8° 45′ 59″. On August 22 it will be near the bright star Regulus. In July there will be two eclipses, both invisible in the United States: a total eclipse of the moon July 4, and a partial eclipse of the sun July 18.

The phases of the moon for the months of July and August are as follows:

Full Moon	July	4	at 4 A.M.	C.S.T.
Last Quarter		11	" 6 P.M.	"
New Moon		18	" 9 A.M.	"
First Quarter		27	" 1 P.M.	"
Full Moon	Aug.	2	" 11 A.M.	"
Last Quarter		9	" 2 A.M.	"
New Moon		17	" 12 A.M.	"
First Quarter		25	" 1 A.M.	"

The moon will be at apogee on July 21 and again on August 18. On July 6, and August 3 and 31 it will be at perigee.

Mercury sets a little more than an hour and a half after sunset on August 22. On this date it will be found about 2.5 degrees south of β Virginis. Its stellar magnitude on this date is about +0.5 and the ratio of the area of the illuminated portion of the apparent disk to the area of the apparent disk regarded as circular 0.57.

Venus may be seen in the western sky after sunset. On July 1 it will be found near the eastern boundary of Cancer. On August 4 its stellar magnitude will be −3.3.

Mars will be a morning star, rising on July 1 about an hour before the sun. During the two months it will move from the constellation of Taurus into Gemini.

Jupiter will be found in the morning sky, rising earlier each succeeding day. It will be found in the constellation of Taurus. Its stellar magnitude on August 7 will be −1.8.

Saturn will not be visible during the two months.

Uranus may be seen with the aid of a telescope in the constellation of Capricornus. About the middle of August it will be opposite the sun.

Neptune during the latter part of July and August will be too near the sun to be observed.

Occultations Visible at Washington.

[*From the American Ephemeris*].

Date 1917	Star's Name	Magnitude	IMMERSION. Washington M.T. h m	IMMERSION. Angle f'm N. °	EMERSION. Washington M.T. h m	EMERSION. Angle f'm N. °	Duration h m
July 1	50 B Scorpii	6.4	9 18	26	9 41	354	0 23
3	70 B Sagittarii	6.4	15 26	154	15 36	173	0 10
4	222 B Sagittarii	5.5	12 48	80	14 2	238	1 15
4	50 Sagittarii	5.5	15 56	66	16 57	249	1 1
27	18 G Librae	6.1	10 55	59	11 46	317	0 50
Aug. 5	16 Piscium	5.7	8 47	26	9 30	282	0 43
5	19 Piscium	5.4	14 19	53	15 34	235	1 15
6	136 B Piscium	6.5	14 30	95	15 30	196	1 0
7	101 Piscium	6.2	14 30	94	15 33	203	1 3
10	62 Tauri	6.1	15 13	19	15 52	311	0 39
12	8 Geminorum	6.1	16 1	27	16 34	329	0 33
12	9 Geminorum	6.2	16 2	91	17 13	266	1 11
28	222 B Sagittarii	5.5	9 51	116	10 41	200	0 50
28	50 Sagittarii	5.5	12 51	99	13 42	217	0 51
30	72 B Aquarii	6.5	15 2	342	15 14	319	0 12

VARIABLE STARS.

Minima of Variable Stars of Short Period.

[Calculated by Lois N. Wilson at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5h; Central Standard 6h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1917 July-Aug.							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8			16 21				20	19
RT Sculptor.	31.5	−26 13	9.6—10.5	0 12.3	7 16;	23 0;	7 8;	22	17			
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	7 18;	22 14;	6 11;	21	8			
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	6 17;	21 16;	5 14;	20	13			
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	9 15;	21 20;	9 5;	21	10			
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	9 1;	23 8;	13 18;	28	1			
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	12 0;	25 18;	8 11;	22	5			
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	6 21;	21 6;	11 18;	26	2			
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	13 4;	30 18;	8 12;	26	2			
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	9 8;	25 6;	10 3;	26	0			
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6	11 7		12 15					
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	11 8;	22 20;	9 0;	20	12			
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	6 12;	20 2;	9 12;	23	2			
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	1 23;	17 18;	10 12;	26	7			
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	2 17;	19 7;	13 5;	29	20			
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	14 1;	29 20;	14 14;	30	9			
RW Persei	13.3	+42 04	8.8—11.0	15 04.8	7 5;	20 9;	2 14;	29	0			
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	9 4;	28 1;	6 12;	25	9			
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1	2 23;	27 19;	9 5;	21	15			
TT Aurigae	5 02.8	+39 27	7.8— 8.7	0 16.0	8 4;	21 12;	10 12;	23	20			
RY Aurigae	11.5	+38 13	10.7—11.7	2 17.5	1 20;	18 4;	3 13;	19	22			
RZ Aurigae	42.9	+31 40	10.6—13.3	3 00.3	8 7;	20 8;	7 10;	25	11			
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	3 15;	20 23;	9 7;	24	15			
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	8 10;	29 6;	8 15;	29	11			
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	9 7;	25 7;	10 8;	26	9			
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	7 11;	24 16;	10 21;	28	1			
U Columbae	6 11.2	−33 03	9.2—10.0	2 19.2	9 0;	25 19;	11 15;	22	19			
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	13 9;	29 19;	15 5;	31	14			
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	6 13;	21 19;	13 16;	28	22			
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	2 18;	27 4;	8 9;	20	14			
RU Monoc.	6 49.4	− 7 28	9.8—10.5	0 21.5	5 3;	19 11;	9 23;	24	7			
R Can. Maj.	7 14.9	−16 12	5.8— 6.4	1 03.3	4 23;	18 14;	8 1;	21	16			
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	9 7;	27 21;	6 5;	24	19			
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	6 18;	19 23;	2 5;	15	10			
TX Gemin.	30.3	+17 8	10.0—11.9	2 19.2	9 5;	26 0;	11 20;	29	15			
RR Puppis	43.5	−41 08	9.4—10.7	6 10.3	9 20;	22 17;	11 0;	24	20			
V Puppis	7 55.4	−48 58	4.1— 4.8	1 10.9	3 15;	18 4;	9 0;	23	13			
X Carinae	8 29.1	−58 53	7.9— 8.7	0 13.0	9 12;	25 18;	11 0;	27	5			
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	10 23;	29 22;	8 10;	27	9			
RX Hydrae	9 00.8	− 7 52	9.1—10.5	2 6.8	11 6;	24 23;	15 11;	28	4			
S Velorum	29.4	−44 46	7.8— 9.3	5 22.4	7 13;	25 8;	6 5;	18	2			
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	10 4;	23 16;	12 21;	26	9			
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	9 0;	23 20;	7 16;	22	12			
SS Carinae	10 54.2	−61 23	12.2—12.8	3 07.2	12 4;	25 9;	14 4;	27	9			
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	13 10;	31 0;	8 19;	26	10			
RW Urs. Maj.	35.4	−52 34	10.3—11.4	7 07.9	3 1;	17 17;	8 16;	23	8			
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	12 11;	26 1;	8 15;	22	5			
RZ Centauri	12 55.6	−64 05	8.5— 8.9	1 21.0	14 12;	29 12;	13 12;	28	13			
RS Can. Ven.	13 06.3	+36 28	7.5—12.5	4 19.2	10 1;	29 6;	7 20;	27	1			
SS Centauri	13 07.2	−63 37	8.8—10.4	2 11.5	2 8;	17 5;	8 12;	23	9			
δ Librae	14 55.6	− 8 07	4.8— 6.2	2 07.9	11 0;	24 23;	7 23;	21	22			

Minima of Variable Stars of Short Period—Continued.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1917 July-Aug.							
	h m	° ′		d h	d	h	d	h	d	h	d	h
U Coronae	15 14.1	+32 01	7.6— 8.7	3 10.9	12	7;	26	2;	8	21;	22	17
TW Draconis	32.4	+64 14	7.3— 8.9	2 19.4	3	13;	22	9;	8	5;	25	1
SS Librae	15 43.4	−15 14	9.3—11.5	0 18.4	13	0;	28	7;	12	15;	27	22
SW Ophiuchi	16 11.1	− 6 44	9.2—10.0	2 10.7	4	8;	19	0;	10	0;	24	17
SX Ophiuchi	12.6	− 6 25	10.5—11.2	2 01.5	5	21;	22	9;	7	21;	24	10
R Arae	31.1	−56 48	6.8— 7.9	4 10.2	5	4;	22	20;	9	13;	27	6
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1	1	16;	22	10;	12	5;	23	6
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	10	11;	24	2;	13	13;	27	3
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	6	15;	23	10;	17	13;	25	23
u Herculis	13.6	+33 12	4.6— 5.4	2 01.2	9	21;	22	5;	9	16;	21	23
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	8	14;	23	0;	13	15;	28	1
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	13	19;	28	13;	12	7;	27	1
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	5	19;	22	4;	7	13;	23	21
TX Scorpii	48.6	−34 13	7.5— 8.2	0 22.6	9	14;	24	16;	8	18;	23	20
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	1	8;	16	20;	9	2;	24	13
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	9	6;	25	5;	10	4;	26	4
WX Sagittae	53.6	−17 24	9.2—10.8	2 03.1	2	18;	19	19;	5	19;	22	20
WY Sagittae	17 54.9	−23 1	9.5—10.6	4 16.0	4	2;	22	19;	10	11;	29	3
SX Draconis	18 03.0	+ 58 23	9.3—10.5	5 04.1	2	17;	23	10;	2	18;	23	10
RS Sagittarii	11.0	−34 08	5.9— 6.3	2 10.0	9	21;	24	9;	7	21;	22	9
V Serpentis	11.1	−15 34	9.5—11.1	3 10.9	16	19;	30	14;	13	10;	28	6
RZ Scuti	21.1	− 9 15	7.4— 8.3	15 03.2	15	0;	30	3;	14	6;	29	9
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	4	20;	19	3;	2	11;	23	23
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	11	4;	25	10;	8	15;	23	21
SX Sagittarii	39.7	−30 36	8.7— 9.8	2 01.8	11	0;	27	15;	13	6;	29	20
RR Draconis	40.8	+62 34	9.3—13	2 19.9	7	17;	24	16;	10	16;	27	15
RS Scuti	43.7	−10 21	9.3—10.3	0 15.9	6	17;	20	0;	8	23;	22	5
β Lyrae	46.4	+33 15	3.4— 4.1	12 21.8	1	23;	27	19;	9	17;	22	14
U Scuti	18 48.9	−12 44	9.1— 9.6	0 22.9	5	21;	21	3;	5	10;	20	17
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	3	17;	18	21;	10	14;	25	17
RV Lyrae	12.5	+32 15	11. —12.8	3 14.4	6	15;	21	0;	4	10;	18	19
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	2	5;	20	3;	16	0;	24	23
U Sagittae	14.4	+19 26	6.5— 9.0	3 09.1	7	0;	20	13;	9	20;	23	8
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	7	20;	22	13;	13	16;	28	9
TT Lyrae	24.3	+41 30	9.3—11.6	5 05.8	6	8;	22	1;	6	19;	22	12
UZ Draconis	26.1	+68 44	9.0— 9.8	1 15.1	5	8;	24	22;	13	12;	26	13
SY Cygni	19 42.7	+32 28	10 —12	6 00.2	9	23;	21	23;	8	23;	27	0
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	7	2;	20	9;	9	6;	22	13
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	12	9;	30	16;	8	19;	27	2
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	5	6;	22	3;	7	23;	24	20
RW Capric.	12.2	−17 59	8.8—10.6	3 09.4	11	3;	24	16;	7	6;	20	19
UW Cygni	19.6	+42 55	10.5—10.8	3 10.8	5	13;	19	8;	9	1;	22	21
V Vulpec.	32.3	+26 15	8.2—9.8	37 19.0			27	11				
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	8	5;	27	11;	6	1;	25	7
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	6	17;	25	3;	3	7;	21	17
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	8	13;	23	12;	14	23;	29	23
WZ Cygni	49.3	+38 27	9.9—10.8	0 14.0	3	14;	18	19;	3	0;	18	4
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	8	15;	28	19;	7	22;	28	3
VV Cygni	21 02.3	+45 23	12.1—13.8	1 11.4	3	17;	18	12;	2	6;	17	0
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	2	23;	22	8;	10	17;	30	3
RY Aquarii	14.8	−11 14	8.8—10.4	1 23.2	14	6;	30	0;	6	20;	22	15
RT Lacertae	21 57.4	+43 24	9.1—10.5	5 01.7	2	23;	23	6;	2	8;	22	16
UZ Cygni	55.2	+43 52	8.9—11.6	31 07.3			31	2;	31	9		
RW Lacertae	22 40.6	+49 08	10.2—11.2	5 04.4	10	22;	26	12;	11	1;	26	15
TT Androm.	23 08.7	+45 36	11.3—12.6	2 18.3	11	6;	27	20;	13	10;	30	0
Y Piscium	29.3	+ 7 22	9.0—12.0	3 18.4	14	14;	29	15;	13	17;	28	18
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	14	0;	30	11;	7	17;	24	5

Maxima of Variable Stars of Short Period.

[Calculated by Julia M. Hawkes at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5h; Central standard time 6h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1917.							
								July-Aug.				
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.2	36 13.7	12 13				18 3			
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 1.7	9 20;	26 3;	11 10;	27 16				
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	7 23;	23 12;	7 22;	23 10				
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2	3 17;	18 12;	2 7;	31 22				
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	15 5;	31 2;	15 23;	31 20				
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	5 7;	20 21;	5 11;	21 1				
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	9 12;	24 1;	7 15;	22 5				
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0	15	31	16					
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	13 10;	30 14;	8 4;	25 8				
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	4 6;	26 12;	6 16;	28 22				
RX Aurigae	4 54.5	+39 49	7.2— 8.1	11 15.0	9 18;	21 9;	2 0;	25 6				
SX Aurigae	5 04.6	+42 02	8.0— 8.7	1 12.8	4 10;	19 18;	4 1;	19 9				
SY Aurigae	05.5	+42 41	8.4— 9.5	10 03.3	1 18;	22 1;	11 7;	31 14				
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.6	7 12;	22 23;	15 3;	30 13				
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	5 8;	16 9;	7 12;	24 2				
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	4 18;	19 21;	4 0;	19 3				
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3		27 23		23 23				
RT Aurigae	23.0	+30 33	5.1— 6.0	3 17.5	6 0;	20 22;	12 7;	27 4				
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	3 7;	17 17;	8 7;	22 17				
W Gemin.	29.2	+15 24	6.7— 7.5	7 22.0	9 20;	25 16;	10 12;	26 8				
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	3 19;	24 3;	3 6;	23 14				
RU Camelop.	7 10.9	+69 51	8.5— 9.8	12 06.5	18 4		9 11;	31 17				
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	5 22;	21 19;	6 17;	22 14				
V Carinae	8 26.7	−59 47	7.4— 8.1	6 16.7	3 22;	23 23;	6 9;	19 18				
T Velorum	8 34.4	−47 01	7.6— 8.5	4 15.3	5 14;	24 3;	2 10;	20 23				
V Velorum	9 19.2	−55 32	7.5— 8.2	4 08.9	1 22;	19 9;	5 21;	23 8				
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	3 14;	23 23;	6 12;	20 2				
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	4 5;	24 0;	6 5;	19 11				
S Muscae	12 07.4	−69 36	6.4— 7.3	9 15.8	2 11;	21 18;	10 2;	29 9				
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	2 7;	18 6;	3 5;	19 3				
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	7 4;	20 15;	9 20;	23 7				
R Crucis	18.1	−61 04	6.8— 7.9	5 19.8	7 6;	24 17;	11 5;	22 20				
S Crucis	12 48.4	−57 53	6.5— 7.6	4 16.6	4 13;	18 15;	6 9;	20 11				
W Virginis	13 20.9	− 2 52	8.7—10.4	17 06.5	2 21;	20 4;	6 10;	23 16				
SS Hydrae	25.0	−23 08	7.4— 8.1	8 4.8	3 5;	19 15;	5 0;	21 10				
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	4 0;	18 1;	8 2;	22 3				
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	1 5;	17 15;	3 1;	19 11				
V Centauri	25.4	−56 27	6.4— 7.8	5 11.9	4 23;	21 11;	6 23;	23 10				
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	2 12;	17 15;	9 6;	24 8				
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	6 15;	21 11;	5 7;	20 3				
R Triang. Austr.	15 10.8	−66 08	6.7— 7.4	3 09.3	3 22;	24 6;	6 19;	20 8				
S Triang. Austr.	15 52.2	−63 29	6.4— 7.4	6 07.8	12 9;	25 1;	6 16;	19 8				
S Normae	16 10.6	−57 39	6.6— 7.6	9 18.1	7 8;	26 20;	5 14;	25 2				
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	1 11;	19 4;	5 21;	23 14				
RV Scorpii	16 51.8	−33 27	6.7— 7.4	6 01.5	5 14;	23 18;	4 21;	23 2				
X Sagittarii	17 41.3	−27 48	4.4— 5.0	7 00.3	4 17;	18 18;	1 18;	15 19				
Y Ophiuchi	47.3	− 6 07	6.1— 6.5	17 02.9	4 22;	22 1;	8 4;	25 7				
W Sagittarii	17 58.6	−29 35	4.3— 5.1	7 14.3	8 6;	23 10;	7 15;	22 19				
Y Sagittarii	18 15.5	−18 54	5.4— 6.2	5 18.6	5 22;	23 6;	3 18;	21 2				
U Sagittarii	26.0	−19 12	6.5— 7.3	6 17.9	6 18;	27 0;	2 18;	22 23				
Y Scuti	32.6	− 8 27	8.7— 9.2	10 08.3	8 18;	29 0;	8 9;	29 2				
Y Lyrae	34.2	+43 52	11.3—12.3	0 12.1	2 12;	20 15;	7 17;	19 19				
RZ Lyrae	39.9	+32 42	9.9—11.2	0 12.3	3 14;	21 23;	9 9;	21 16				
RT Scuti	44.1	−10 30	9.1— 9.7	0 11.9	6 15;	24 12;	25 9;	23 5				
κ Pavonis	18 46.6	−67 22	3.8— 5.2	9 02.2	1 16;	19 20;	7 0;	25 5				

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1916. July-Aug.							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
U Aquilae	19 24.0	− 7 15	6.2— 6.9	7 00.6	5 14;	19 15;	9 17;	23 18				
XZ Cygni	19 30.4	+56 10	8.6— 9.3	0 11.2	4 3;	18 3;	8 2;	29 2				
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	4 5;	20 4;	5 4;	21 3				
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	7 4;	22 14;	14 16;	30 0				
η Aquilae	47.4	+ 0 45	3.7— 4.5	7 04.2	5 3;	19 12;	10 0;	24 9				
S Sagittae	51.5	+16 22	5.6— 6.4	8 09.2	3 4;	19 23;	14 2;	30 20				
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	3 11;	22 10;	4 1;	23 0				
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3	4 17;	21 2;	6 11;	22 20				
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	6 22;	20 5;	6 23;	20 6				
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	7 18;	27 23;	10 10;	23 21				
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	6 1;	19 11;	8 15;	22 1				
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4	6 13;	21 6;	5 0;	19 17				
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	6 14;	22 7;	7 0;	22 18				
SW Aquarii	10.2	— 0 20	9.9—10.8	0 11.0	5 16;	19 11;	2 6;	22 22				
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	4 17;	19 8;	2 22;	22 9				
Y Lacertae	22 05.2	+50 33	9.1— 9.6	4 07.8	3 11;	20 18;	7 2;	24 9				
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	5 1;	21 3;	6 5;	22 8				
Z Lacertae	36.9	+56 18	8.2— 9.0	10 21.1	3 1;	24 19;	4 16;	26 11				
RR Lacertae	37.5	+55 55	8.5— 9.2	6 10.1	2 8;	21 14;	9 21;	22 17				
V Lacertae	22 44.5	+55 48	8.5— 9.5	4 23.6	5 22;	25 20;	9 18;	24 17				
X Lacertae	45.0	+55 54	8.2— 8.6	5 10.7	6 13;	22 21;	8 5;	24 13				
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	5 22;	22 6;	7 14;	23 21				
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	2 22;	21 19;	9 17;	28 14				
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4	12 11;	24 15;	5 18;	30 1				
V Cephei	23 51.7	+82 38	6.0—7.0	0 23.6	10 9;	25 8;	9 7;	19 6				

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, April-May, 1917.

Resuming his duties after a four months' absence the Secretary extends a hearty greeting to the members of the Association.

The thanks of the Association are herewith tendered to Mr. John J. Crane of Sandwich, Mass., to whom we are deeply indebted for so ably filling the post of Secretary during the past three months. The reports have been carefully prepared, and forwarded promptly for publication, the necessary correspondence faithfully attended to, and all records placed on file. This has all taken much time and thought and we are very grateful to Mr. Crane for the valuable service he has rendered the Association.

We are indebted to Signor Lacchini for securing a new Italian member, and heartily welcome to our ranks Signor Domenico Benini, "Be", of Faenza, Italy. Signor Lacchini's report for last month arrived too late for publication and is included herewith. This month he contributes a valuable list of 185 observations. Our foreign members are setting us a splendid example. Mr. Luyten of Deventer, Holland, leads in the number of observations contributed this month. His list contained 360 estimates.

Messrs. Bancroft, McAteer, and Pickering are to be commended for the large number of valuable early morning observations contributed to this report. Mr. McAteer's observations of the little observed variables in Scorpius are of special

VARIABLE STAR OBSERVATIONS April-May, 1917.

Mar. 0 = 2421288 ; Apr. 0 = 2421319; May 0 = J. D. 2421349

001755
T Cassiop.

J.D.	Est	Obs.
242		
1310.3	9.7	Lt
11.3	9.8	Lt
12.6	9.8	Lt
15.3	9.8	Lt

004148
RX Cephei

1305.4	7.4	Lt
07.5	7.5	Lt
11.3	7.4	Lt
15.3	7.4	Lt

011272
S Cassiop.

1303.3	10.1	Lt
03.3	9.8	Hd
05.4	10.4	Hd
11.3	10.4	Hd
12.3	10.4	Hd

015354
U Persei

1303.4	9.8	Lt
16.6	10.5	Ba
17.5	10.1	B

021024
R Arietis

1296.3	9.1	Lt
99.3	8.4	Pe
1303.3	8.7	Lt
03.3	8.5	Vo
05.3	8.7	Lt
05.3	8.4	Vo
06.3	8.5	Lt
07.3	8.3	Vo
10.3	8.5	Lt
11.3	8.4	Lt
12.3	8.5	Lt
12.3	7.8	Vo
15.3	8.3	Lt

021143a
W Androm.

1273.4	10.1	Lt
86.3	9.4	Lt
96.3	8.8	Lt
1303.3	8.4	Lt
05.3	8.1	Lt
06.3	8.0	Lt
07.4	8.0	Lt
10.3	7.7	Lt
11.3	7.6	Lt
12.3	7.6	Lt
15.3	7.6	Lt

021281
Z Cephei

1337.6<11.0		V

021403
o Ceti

J.D.	Est.	Obs.
242		
1269.3	5.5	Be
70.3	5.3	L
71.3	5.2	Be
71.3	5.3	L
73.3	5.4	L
75.3	5.6	Be
75.3	5.4	L
76.3	5.4	L
80.3	5.5	L
82.3	5.7	L
84.3	5.8	L
85.3	5.7	L
88.2	6.9	Lt
88.3	5.8	L
89.3	5.7	L
89.3	6.0	Vo
92.3	7.0	Lt
92.3	5.8	L
97.3	6.1	L
98.2	6.5	Pe
98.3	6.2	L
99.2	6.7	Pe
1304.3	6.5	L
05.3	6.6	L
08.3	6.7	L

021558
S Persei

1316.6	9.0	Ba
41.6	9.6	Ba

023080
RR Cephei

1337.6<11.0		V

024217
T Arietis

1303.3	9.7	Lt
10.3	9.6	Lt

024356
W Persei

1316.6	9.0	Ba
33.6	9.0	Hu
37.6	10.2	Wh
41.6	10.0	Ba

031401
X Ceti

1315.7	8.8	F

032043
Y Persei

1316.6	9.5	Ba
17.6	9.7	B
23.5	9.4	Nt
28.6	9.9	B
33.6	8.9	Hu

033362
U Camelop.

J.D.	Est.	Obs.
242		
1316.6	7.1	Ba
33.5	8.5	Pi
37.6	7.5	Wh
41.6	7.0	Ba

035915
V Eridani

1315.7	8.8	F

042215
W Tauri

1299.3	12.3	Pe
1313.3	12.3	Pe
22.6<11.4		Bu
33.6<12.1		B

042209
R Tauri

1315.7	9.6	F
17.6	9.8	Ba
22.6<11.1		Bu

042309
S Tauri

1315.7<12.0		F
17.6	11.5±	Ba
22.6	11.1	Bu
29.6	10.8	B

043065
T Camelop.

1305.3	8.9	Lt
07.4	8.8	Lt
09.5	8.8	Lt
10.3	8.8	Lt
11.3	8.8	Lt
12.5	8.8	Lt
14.4	8.8	Lt
15.3	8.8	Lt
16.6	8.8	Ba
22.6	8.9	Bu
33.5	8.8	Pi
35.6	8.7	M
41.6	8.4	Ba

043208
RX Tauri

1322.6<11.9		Bu

043274
X Camelop.

1316.5	12.2	Ba
22.6	11.3	Bu
30.6	11.0	Cr
33.5	10.3	Pi
33.6	10.4	Cr
35.6	9.9	O
35.6	10.0	M
35.6	10.3	Cr
37.6<11.1		V
41.5	9.9	O
41.6	9.5	Ba
47.6	8.8	Ba
51.6	8.6	Ba
52.6	8.5	O

044617
V Tauri

J.D.	Est.	Obs.
242		
1322.6	11.0	Bu

045307
R Orionis

1316.6	10.4	Ba
25.6	9.9	B

045514
R Leporis

1282.3	7.9	L
85.3	8.4	L
88.3	8.5	Lt
88.3	7.9	Lt
1303.3	8.6	Lt
05.3	8.6	Lt
05.3	9.1	L
17.3	9.0	L
25.6	9.2	B

050003
V Orionis

1328.5<12.3		Nt

050022
T Leporis

1271.3	8.8	L
84.3	10.0	L
99.7<11.4		F
1305.3	10.4	L

050953
R Aurigae

1322.6	9.1	Bu
41.6	11.5	Ba

051533
T Columbae

1299.7	11.6	F

052034
S Aurigae

1316.6	10.0	Ba
22.6	10.3	Bu
23.5	10.1	Nt
25.6	9.5	B
36.6	11.0	Wh
38.6	10.5	M
41.6	10.3	Bu
41.6	10.0	Ba

052036
W Aurigae

1316,6	10.9	Ba
22.6	11.2	Bu
33.6	11.6	B
36.6	11.5	Wh
40.6	11.4	M
41.6	12.2	Bu
41.6<12.0		Ba

052404
S Orionis

J.D.	Est.	Obs.
242		
1288.3	9.3	Lt
1303.3	9.7	Lt
05.3	9.7	Lt
25.6	10.0	B

053005a
T Orionis

1271.3	10.5	L
80.4	10.1	L
85.4	10.0	L
88.7	11.2	By
93.7	11.0	By
99.3	9.8	Pe
1304.3	10.2	L
13.3	10.5	Pe
16.6	9.8	Ba
22.3	9.9	L
23.5	10.6	Wh
25.6	10.2	B
28.5	10.1	Nt

053068
S Camelop.

1303.6	10.0	Lt
10.3	9.8	Lt
11.3	9.8	Lt
12.5	9.8	Lt
14.4	9.8	Lt
15.3	9.7	Lt
22.6	9.5	Bu
33.5	9.2	Pi
35.6	8.9	M
41.6	9.6	Bu
41.6	8.7	Ba

053326
RR Tauri

1322.6<11.6		Bu
41.6<12.1		Bu

053531
U Aurigae

1322.6<11.0		Bu
47.6<12.0		Ba

054331
S Columbae

1311.7	10.5	F

054319
SU Tauri

1271.3	9.5	L
80.3	9.7	L
83.3	10.0	L
84.4	10.0	L
85.3	9.9	L
98.4	9.7	L
1304.4	9.7	L
08.3	9.5	L
16.5	9.2	Ba
17.6	9.3	B

VARIABLE STAR OBSERVATIONS April-May, 1917—Continued.

SU Tauri

J.D. 242	Est.	Obs.
1317.6	9.2	Ba
18.5	9.4	Ba
21.6	9.4	B
22.3	9.4	L
23.5	9.5	Wh
25.6	9.4	B
26.6	9.4	B
28.6	9.6	B
29.6	9.5	B
32.6	9.4	B
33.6	9. 5	B
36.6	9.6	Wh
40.7	9.9	V
41.5	9.6	B
41.6	9.8	Ba
43.5	9.6	B
47.6	9.5	Ba
51.5	9.6	Ba

054920
U Orionis

1299.3	11.5	Pe
1311.7	11.9	F
16.6	10.0	Ba
33.6	10.0	Hu
47.6	9.5	Ba

054974
V Camelop.

1316.5	<13.0	Ba
18.5	<12.8	Ba
30.6	<12.6	Cr
33.5	<12.2	Pi
33.6	<12.2	Cr
33.6	<12.8	Y
34.6	<11.3	M
35.6	<12.6	Cr
35.6	<13.0	Ba
36.6	<12.8	Y
41.6	<13.0	Ba
47.6	<13.0	Ba
51.6	<12.5	Ba
52.6	<12.5	Ba

055353
Z Aurigae

1316.6	10.9	Ba
34.6	11.0	M
41.6	10.8	Pi
41.6	10.8	Wpi
41.6	10.7	Ba

055331
U Aurigae

1343.6	<12.9	B

060450
X Aurigae

1316.6	8.7	Ba
25.6	8.2	B
34.6	8.4	M
35.6	8.2	Bu
36.6	8.6	Wh

X Aurigae

J.D. 242	Est.	Obs.
1340.6	8.6	V
41.6	8.5	Pi
41.6	8.5	Wpi
41.6	8.3	Ba

060547
SS Aurigae

1273.3	10.6	L
75.3	10.6	L
76.3	10.8	L
80.3	12.0	L
80.4	12.6	L
82.4	<12.4	L
88.4	<11.0	L
98.4	<11.3	L
1304.4	<12.4	L
08.3	<12.4	L
16.5	<13.0	Ba
17.4	<11.0	L
17.5	12.9	Ba
17.5	12.9	Ba
17.6	12.7	Ba
18.7	10.9	Ba
22.3	<11.6	L
22.6	12.8	Y
22.6	<11.0	Bu
23.5	<12.8	Y
23.6	<11.0	Bu
26.6	<12.4	B
28.6	<12.4	B
29.6	<12.4	B
30.6	<12.4	Wh
30.6	<12.4	Cr
32.6	<12.4	B
33.6	<11.0	Cr
33.6	<12.4	B
34.6	<11.6	M
35.6	<11.4	Bu
35.6	<12.4	Cr
35.6	<13.0	Ba
37.6	<11.0	V
38.6	<11.4	Bu
41.6	<13.0	Ba
41.6	<11.0	O
41.6	13.6	B
41.6	<12.0	Bu
41.6	<12.4	Pi
41.6	<12.4	Wpi
42.6	13.6	B
43.6	<11.4	Bu
44.6	<11.4	Bu
47.5	<13.0	Ba
51.6	<12.5	Ba
52.6	<12.5	Ba

061647
V Aurigae

1333.6	12.4	B
33.6	12.0	Y
42.6	12.6	B
47.6	12.8	Ba

061702
V Monoc.

J..D 242	Est.	Obs.
1332.6	<11.1	Pi

062230
RT Aurigae

1270.31	5.6	L
71.27	5.1	Be
71.27	4.9	L
72.42	5.5	L
73.26	5.3	Be
73.28	5.6	L
75.26	5.2	Be
75.28	5.2	L
76.30	5.6	L
80.27	5.7	L
80.42	5.5	L
81.27	5.7	Be
81.27	5.4	L
82.28	5.0	L
82.43	5.0	L
83.27	4.9	Be
83.32	5.2	L
84.27	5.6	L
84.44	5.5	L
85.27	5.3	L
86.26	5.2	L
87.32	5.7	L
88.27	5.8	L
88.43	5.4	L
89.28	4.9	L
92.27	5.4	L
97.27	5.1	L
98 28	5.3	L
1304.29	5.0	L
05.28	5.0	L
08.28	5.0	L
22.29	5.6	L

063159
U Lyncis

1341.6	<13.6	Ba

063308
R Monoc.

1317.6	11.4	B
29,6	<12.4	B
32.6	<11.4	Pi
33.6	<12.0	B
36.6	11.3	Wh
44.5	<11.8	B

063558
S Lyncis

1303.4	<11.0	Hd
05.4	<11.0	Hd
11.4	<11.0	Hk
12.4	<11.0	Hd
41.6	<13.0	Ba

064030
X Gemin.

J.D. 242	Est.	Obs.
1296.5	9.5	Lt
1305.3	9.0	Lt
07.4	8.6	Lt
09.4	8.6	Lt
10.3	8.6	Lt
11.3	8.6	Lt
12.5	8.6	Lt
15.3	8.6	Lt
23.6	8.6	Nt
34.6	8.8	M
40.6	7.7	V
41.6	8.2	Ba

064707
W Monoc.

1332.6	10.7	Pi
32.6	10.3	Wpi

064932
Nova Gemin.

1283.3	<11.7	L

065111
Y Monoc.

1289.2	<8.6	Vo
1303.4	9.7	Lt
10.3	9.8	Lt
11.3	10.1	Lt
12.5	10.1	Lt
23.5	10.1	Nt
35.5	10.2	M
35.5	11.4	Bu
40.6	<11.2	V

065208
X Monoc.

1270.3	7.7	L
82.3	7.5	L
86.3	7.2	L
1305.3	8.0	L
22.3	8.4	L
23.6	9.2	Bu
35.5	9.4	M

065355
R Lyncis

1273.5	10.3	Lt
86.7	9.4	Lt
96.4	9.1	Lt
1303.4	8.9	Lt
05.4	8.8	Lt
06.7	<8.0	Vo
07.5	8.8	Lt
09.4	8.8	Lt
10.3	8.8	Lt
11.3	8.8	Lt
11.7	8.8	Vo
12.5	8.8	Lt
12.7	8.7	Vo
14.4	8.8	Lt

R Lyncis

J.D. 242	Est.	Obs.
1315.4	8.8	Lt
15.7	8.6	Vo
23.5	8.6	Y
23.6	8.2	Nt
28.6	8.8	B
35.6	8.8	M
41.6	8.4	Ba

070109
V Can. Min.

1341.5	<11.1	Pi

070122a
R Gemin.

1299.3	11.9	Pe
1313.4	11.9	Pe
23.6	11.3	Nt
32.6	12.2	B
33.6	12.4	Hu
35.6	<10.8	M
36.6	<11.6	Wh
41.6	12.3	B
41.6	12.4	Bu
41.6	12.3	Ba

070122b
Z Gemin.

1299.3	<12.1	Pe
1323.6	<11.6	Nt
35.6	<10.8	M
36.7	<11.6	Wh
41.6	<12.4	Bu
41.6	12.5	Ba

070122c
TW Gemin.

1299.3	8.4	Pe
1313.4	8.2	Pe
23.6	8.2	Nt
35.6	8.3	M
36.6	8.3	Wh
41.6	8.3	Bu
41.6	8.0	Ba

070310
R Can. Min.

1282.4	10.7	L
84.4	10.5	L
98.3	9.7	L
1317.3	9.4	L
17.6	8.7	Ba
25.6	8.8	B
34.6	9.2	M
41.6	8.9	Pi
41.6	8.9	Wpi
41.6	8.4	Ba

071201
RR Monoc.

1323.6	8.2	Nt

VARIABLE STAR OBSERVATIONS April-May, 1917—Continued.

071713
V Gemin.

J.D. 242	Est.	Obs.
1296.4	8.4	Lt
1303.5	8.6	Lt
07.4	8.8	Lt
09.4	8.9	Lt
10.3	8.9	Lt
11.3	9.0	Lt
12.5	9.0	Lt
15.3	9.1	Lt
17.6	9.0	Ba
22.6	9.0	Y
23.6	9.4	Nt
40.6	9.9	V
41.6	10.2	Ba
44.6	10.6	Wh

072708
S Can. Min.

1298.2	11.5	Pe
1313.3	11.8	Pe
17.6	12.0	Ba
33.6	12.1	B
34.6	11.3	M
34.7<10.0		Mu
36.7<12.0		Wh
41.5<11.0		Pi
41.5<11.0		Wpi
41.6	12.3	Ba
42.6	12.2	B
43.6	12.1	Bu

072811
T Can. Min.

1338.6<13.0		Y
41.6<12.1		Ba

073508
U Can. Min.

1282.3	9.5	L
84.4	9.3	L
98.3	9.2	L
1317.3	9.1	L
17.6	8.9	Ba
21.6	8.6	B
34.6	9.1	M
41.6	8.7	Pi
41.6	9.0	Wpi
41.6	8.8	O
41.6	8.8	Ba
43.6	9.2	Bu

073723
S Gemin.

1286.5	10.1	Lt
96.5	9.3	Lt
1303.5	8.8	Lt
07.4	8.5	Lt
09.4	8.6	Lt
10.3	8.6	Lt
11.3	8.7	Lt
15.3	8.6	Lt
17.6	8.3	Ba

S Gemin.

J.D. 242	Est.	Obs.
1328.6	8.8	B
30.6	8.8	Wh
33.5	9.2	Pi
33.6	8.9	Hu
35.6	9.5	M
40.6	9.2	V
41.6	9.7	O
41.6	9.6	Bu
47.6	9.7	Ba
52.6	9.9	O

074323
T Gemin.

1317.6	10.3	Ba
33.5	10.0	Pi
35.6	9.8	M
40.7	9.5	V
41.6	10.0	O
42.6	9.6	Wh
47.6	9.5	Ba
52.6	9.5	O

074922
U Gemin.

1270.3<12.3		L
71.3<12.3		L
75.3<10.9		L
76.3<12.4		L
80.3<12.4		L
81.3<12.3		L
82.3<12.3		L
83.3<12.3		L
84.3<12.4		L
85.3<12.3		L
88.3<11.4		L
89.3<10.9		L
98.3<12.4		L
1304.6<12.4		L
05.3<12.4		L
08.3<12.3		L
16.5<13.5		Ba
17.3<11.7		L
17.6<12.4		B
17.6<13.3		Ba
18.6<12.5		Ba
21.6<11.5		B
22.3<11.4		L
22.6<12.6		Y
22.6<11.7		Bu
23.6<11.7		Bu
23.6<12.4		Y
25.6<11.0		B
26.6<11.0		B
28.5<13.5		Nt
28.5<12.5		B
29.5<12.6		B
29.6<13.3		Y
30.6<12.4		Wh
30.6<11.7		Cr
32.5<12.6		B

U Gemin.

J.D. 242	Est.	Obs.
1333.5<12.4		Y
33.5<12.4		Pi
33.6<12.5		Hu
33.6<12.6		B
33.6<11.7		Cr
35.6<12.4		Bu
35.6<12.3		M
35.6	13.7	Ba
36.6<13.3		Y
36.7<12.4		Wh
38.6<12.4		Bu
40.7<11.7		V
41.5<10.9		O
41.5<13.7		B
41.6<12.4		Bu
41.6<13.7		Ba
42.6	13.8	B
43.6<11.7		Bu
43.6	11.5	Nt
43.6<11.4		Y
43.6	11.0	B
44.5	9.3	O
44.5	9.6	B
44.6	9.0	Bu
44.6	9.5	Y
45.6	9.5	Wh
47.6	9.3	Pi
47.6	9.3	Wpi
47.6	9.3	O
47.6	9.7	Hu
47.6	9.8	Ba
51.6	9.9	Ba
52.6	9.8	O
52.6	9.9	Ba

081112
R Cancri

1270.3	8.9	L
82.4	8.8	L
84.4	8.7	L
98.3	8.4	L
1303.5	8.6	Lt
07.4	8.5	Lt
09.4	8.4	Lt
10.3	8.4	Lt
11.3	8.4	Lt
12.4	8.9	Hd
12.5	8.3	Lt
15.3	8.3	Lt
17.6	6.9	Ba
21.6	7.1	B
22.3	6.9	L
23.6	7.0	Nt
33.6	6.5	Hu
35.6	6.6	M
41.6	6.8	O
47.6	6.5	Ba

081617
V Cancri

1343.6	12.8	B

081733
T Lyncis

J.D. 242	Est.	Obs.
1335.6	8.6	M

082405
RT Hydrae

1280.4	7.6	L
1304.4	8.2	L
17.6	8.4	Ba
40.6	8.6	M
47.6	8.2	Ba

083019
U Cancri

1333.6<13.3		Y
38.6<12.9		Y

083350
X Urs. Maj.

1303.4	10.2	Lt
07.4	10.5	Lt
09.5	10.5	Lt
10.3	10.5	Lt
11.4	10.5	Lt
44.6<11.5		Pi
47.6<12.5		Ba

084205
RT Hydrae

1322,6	8.8	Bu

084803
S Hydrae

1317.6	9.0	Ba
22.6	8.4	Bu
28.6	8.4	Nt
33.6	8.2	Hu
35.6	8.2	O
40.6	8.6	M
51.6	8.0	Ba

085008
T Hydrae

1317.6	10.7	Ba
51.6	8.6	Ba

085120
T Cancri

1282.4	9.3	L
1304.3	9.2	L
33.6	9.9	Hu
51.6	8.2	Ba

090151
V Urs. Maj.

1271.3	10.1	L
75.3	10.2	L
81.3	10.1	L
83.3	10.1	L
85.3	10.1	L
88.3	10.0	L
89.3	10.1	L
98.3	10.1	Pe
1304.3	10.1	L
07.7	10.3	L

V Urs. Maj.

J.D. 242	Est.	Obs.
1313.3	10.2	Pe
13.6	10.6	L
15.6	10.4	L
16.6	10.5	L
17.3	10.5	L
22.6	10.6	L
25.6	10.6	B
29.7	10.0	M
33.6	10.5	Hu
34.7	10.4	Mu
40.7	10.7	V
44.6	10.7	Pi
51.6	10.4	Ba

090425
W Cancri

1336.6	13.7	Y

093178
Y Draconis

1336.6	9.3	Y

093934
R Leo. Min.

1296.4	8.7	Lt
1303.3	8.9	Lt
07.5	8.9	Lt
09.5	8.9	Lt
10.3	8.9	Lt
11.3	8.9	Lt
12.5	9.0	Lt
15.4	9.0	Lt
32.6	9.4	Pi
32.6	9.2	Wpi
33.6	8.4	Hu
35.6	8.5	M
36.6	10.2	Me
44.6	10.0	S
51.6	9.5	Ba

094211
R Leonis

1270.3	9.7	L
83.3	10.0	L
86.3	10.0	L
98.3	9.7	Pe
99.3	10.3	Pe
99.7	10.3	Mu
1305.3	10.1	L
05.7	10.2	Mu
07.5	10.1	Lt
09.5	10.1	Lt
10.3	10.0	Lt
11.3	10.1	Lt
12.5	10.1	Lt
13.3	9.8	Pe
15.4	9.9	Lt
17.3	10.0	L
32.6	9.8	Pe
32.6	9.2	Wpi
32.6	9.8	Pi
34.7	9.2	M

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R Leonis

J.D. 242	Est.	Obs.
1335.6	9.3	O
36.6	9.6	Me
36.7	9.3	Wh
41.6	9.3	O
44.6	9.1	S
47.6	9.0	O
51.6	8.0	Ba
52.6	8.8	O

094622 Y Hydrae

J.D. 242	Est.	Obs.
1293.8	7.0	By
1317.6	6.7	Ba
22.6	7.2	Bu
51.6	6.5	Ba

095421 V Leonis

J.D. 242	Est.	Obs.
1332.6 <	11.8	Pi
35.6	12.2	M
36.6	12.6	Y
42.6	12.1	B
51.6	10.8	Ba

103212 U Hydrae

J.D. 242	Est.	Obs.
1280.4	5.0	L
1303.5	5.3	Lt
04.4	4.9	L
05.4	5.3	Lt
05.4	5.7	Pe
06.4	5.6	Pe
07.4	5.3	Lt
09.4	5.2	Lt
10.3	5.2	Lt
11.3	5.3	Lt
12.5	5.2	Lt
13.4	5.7	Pe
15.3	5.3	Lt

103769 R Urs. Maj.

J.D. 242	Est.	Obs.
1303.3 <	10.7	Hd
11.3	11.0	Hd
12.3	11.0	Hd
35.6	13.0	Ba
35.6	13.0	Ba
41.6	13.0	Ba
43.6	13.0	B
44.6 <	11.5	Pi

104620 V Hydrae

J.D. 242	Est.	Obs.
1280.4	6.6	L
1304.4	6.2	L
22.6	7.4	Bu
23.6	7.2	Nt
38.6	7.7	Bu
51.6	6.4	Ba

104814 W Leonis

J.D. 242	Est.	Obs.
1336.6 <	12.9	Y

110506 S Leonis

J.D. 242	Est.	Obs.
1336.6 <	13.0	Y

115919 R Comae Ber.

J.D. 242	Est.	Obs.
1338.6	12.8	Y

115905 RX Virginis

J.D. 242	Est.	Obs.
1283.7	8.4	L
1316.6	8.1	L

120012 SU Virginis

J.D. 242	Est.	Obs.
1335.6	12.5	Ba
38.6	12.1	Y
52.6 <	12.0	Ba

120206 RW Virginis

J.D. 242	Est.	Obs.
1283.7	7.0	L
1316.6	6.9	L

120905 T Virginis

J.D. 242	Est.	Obs.
1328.6	10.8	B
28.6	10.4	Nt
35.6	11.2	Ba
38.6 <	11.1	Bu
40.7 <	11.1	V
44.6	11.2	B

121418 R Corvi

J.D. 242	Est.	Obs.
1296.4	8.0	Lt
1303.5	8.0	Lt
07.5	8.1	Lt
09.5	8.1	Lt
10.4	8.1	Lt
12.5	8.1	Lt
15.4	8.1	Lt
1328.6	9.3	B
33.8	9.2	M
34.6	9.6	Hu
38.6	9.2	Bu

122001 SS Virginis

J.D. 242	Est.	Obs.
1323.6	7.6	Nt
28.6	7.9	B
38.6	9.1	Bu
44.6	8.2	Hu
52.6	7.7	Ba

122532 T Can. Ven.

J.D. 242	Est.	Obs.
1328.6	9.7	Nt
34.6	9.9	M
37.6	10.0	Wh
38.6	9.8	Bu
52.6	9.7	Ba

122803 Y Virginis

J.D. 242	Est.	Obs.
1333.6	9.3	B
38.6	9.4	Y
51.6	9.7	Ba

123160 T Urs. Maj.

J.D. 242	Est.	Obs.
1296.4	8.5	Lt
98.3	8.2	Pe
1303.3	8.9	Lt
05.4	9.0	Lt
07.5	9.0	Lt
09.5	9.0	Lt
10.3	9.0	Lt
11.4	9.0	Lt
12.5	9.0	Lt
13.3	8.8	Pe
15.3	9.0	Lt
26.3	9.0	B
28.6	9.5	Nt
28.8	9.1	M
34.6	10.0	Hu
34.7	9.6	Mu
35.6	9.5	Ba
35.6	9.5	O
37.5	9.5	Wh
41.5	10.0	O
41.6	9.7	Ba
44.6	10.4	S
44.6	10.2	Pi
46.7	9.7	Mu
47.6 <	10.1	Ba

123307 R Virginis

J.D. 242	Est.	Obs.
1283.4	8.8	L
96.5	8.0	Lt
1303.4	7.9	Vo
03.5	7.7	Lt
05.4	7.7	Lt
05.4	7.6	Pe
06.4	7.6	Pe
07.4	7.5	Pe
07.4	7.8	Vo
07.5	7.5	Lt
09.5	7.5	Lt
10.3	7.9	Lt
11.3	7.4	Lt
11.4	7.8	Vo
12.5	7.7	Vo
12.5	7.3	Lt
13.4	7.3	Pe
14.4	7.3	Lt
15.3	7.3	Lt
15.6	7.1	L
28.6	7.0	B
29.7	7.7	M
31.6	7.0	Me
34.6	7.1	Hu
35.6	7.3	Ba

R Virginis

J.D. 242	Est.	Obs.
1347.6	8.5	O
47.6	8.1	S
51.6	8.5	Ba

123459 RS Urs. Maj.

J.D. 242	Est.	Obs.
1328.8 <	11.3	M
34.7	10.7	Mu
35.6	10.6	Ba
37.5	10.4	Wh
41.6	9.8	Bu
44.6	9.9	Pi
46.7	10.0	Mu
47.6	9.6	Ba

123961 S Urs. Maj.

J.D. 242	Est.	Obs.
1280.4	9.2	L
96.4	8.6	Lt
98.3	8.3	Pe
1303.3	8.5	Lt
04.3	8.3	L
05.4	8.5	Lt
07.3	8.2	Pe
07.5	8.5	Lt
09.5	8.4	Lt
10.3	8.4	Lt
12.5	8.3	Lt
13.2	8.1	Pe
15.3	8.3	Lt
15.6	8.1	L
22.3	8.0	L
26.6	7.8	B
28.6	8.3	Nt
28.8	8.7	M
34.6	7.5	Hu
34.7	7.7	Mu
35.6	7.6	Ba
35.6	8.3	O
37.5	8.4	Wh
41.6	8.3	O
41.6	7.6	Ba
44.6	8.5	S
44.6	8.3	Pi
46.7	8.6	Mu
47.6	7.8	Ba

124204 RU Virginis

J.D. 242	Est.	Obs.
1333.6	12.7	B
42.6	13.1	B

124606 U Virginis

J.D. 242	Est.	Obs.
1231.6	9.5	Me
33.6	9.4	B
44.6	9.3	B
47.6	9.1	O
47.6	9.1	S

125705 a RT Virginis

J.D. 242	Est.	Obs.
1283.7	8.5	L
1315.6	9.2	L

125705 b — Virginis

J.D. 242	Est.	Obs.
1283.7	12.1	L

132202 V Virginis

J.D. 242	Est.	Obs.
1332.6	12.7	B
43.6 <	12.6	Y

132422 R Hydrae

J.D. 242	Est.	Obs.
1283.7	8.8	L
89.6	8.5	L
1309.5	7.5	Lt
13.6	7.3	L
16.6	7.1	Lt

132706 S Virginis

J.D. 242	Est.	Obs.
1275.7	7.5	L
89.6	8.1	L
96.4	8.3	Lt
1303.4	8.4	Vo
03.5	8.6	Lt
07.4	8.3	Vo
07.5	8.7	Lt
09.5	8.8	Lt
10.4	8.9	Lt
12.5	9.0	Lt
12.5	8.5	Vo
15.4	9.0	Lt
15.6	8.9	L
29.7	9.1	M
31.6	9.5	Me
34.6	9.0	Hu
43.6	9.4	Y

133273 T Urs. Min.

J.D. 242	Est.	Obs.
1303.3 <	9.0	Vo
12.3 <	10.3	Vo
52.6	10.1	Ba

134440 R Can. Min.

J.D. 242	Est.	Obs.
1288.4	9.8	L
1303.5	10.3	Lt
07.5	10.3	Lt
09.5	10.4	Lt
10.3	10.4	Lt
11.3	10.5	Lt
12.6	10.5	Lt
15.7	10.5	L
28.6	11.8	B
34.6	10.5	M
35.6	11.8	Hu
38.6	10.6	M
47.6 <	11.7	S
47.6	11.6	Ba

VARIABLE STAR OBSERVATIONS, April-May, 1917—Continued.

135908
RR Virginis

J.D.	Est.	Obs.
242		
1352.6	<12.0	Ba

140113
Z Bootis

1343.6	<13.4	Y
52.6	<12.5	Ba

140512
Z Virginis

1343.6	<12.7	Y

141567
U Urs. Min.

1334.6	11.6	M
35.6	11.6	Hu
44.6	11.8	Pi
45.6	11.8	Wh
47.6	12.0	Ba

141954
S Bootis

1286.5	=10.1	Lt
96.5	9.8	Lt
1303.5	9.5	Lt
05.4	9.4	Lt
07.5	9.4	Lt
09.5	9.4	Lt
10.4	9.4	Lt
11.4	9.4	Lt
12.5	9.4	Lt
14.4	9.3	Lt
15.3	9.4	Lt
23.6	8.9	Wh
28.6	8.4	Nt
29.6	8.2	Me
32.6	8.4	Pi
32.6	8.2	WPi
34.6	8.6	Hu
34.6	8.4	M
38.6	8.6	Bu
41.6	8.5	Ba
44.6	8.7	S
51.6	8.6	Ba
52.6	8.8	O

142205
RS Virginis

1343.6	8.9	B
43.6	9.4	Y
52.6	8.3	Ba

142584
R Camelop.

1288.3	8.1	Vo
89.2	8.3	Lt
96.4	8.3	Lt
1303.3	8.3	Vo
03.3	8.4	Lt
05.4	8.5	Lt
07.5	8.5	Lt
09.5	8.5	Lt

R Camelop.

J.D.	Est.	Obs.
242		
1310.3	8.6	Lt
11.3	8.7	Lt
11.3	8.4	Vo
12.3	8.6	Vo
12.5	8.7	Lt
15.3	8.7	Lt
15.3	9.0	Vo
26.6	8.8	B
34.6	9.5	M
35.6	9.2	O
41.5	9.5	O
45.6	9.8	Wh
47.6	10.0	O
51.6	10.0	Ba
52.6	10.3	O

142539
V Bootis

1280.4	8.3	L
88.4	8.1	L
96.4	7.7	Lt
1303.5	7.7	Lt
05.4	7.8	Lt
07.5	7.8	Lt
09.5	7.8	Lt
10.4	7.8	Lt
11.3	7.8	Lt
12.5	7.8	Lt
15.4	7.8	Lt
15.7	7.8	L
29.6	7.0	Me
29.7	7.6	M
32.6	7.8	Pi
32.6	7.8	Wpi
34.6	7.9	Hu
35.6	7.9	O
37.6	7.6	Wh
37.6	7.7	M
38.6	7.8	Bu
46.7	8.3	Mu
47.6	7.8	S
47.6	8.2	Ba
51.6	7.9	Ba
52.6	8.0	O

143227
R Bootis

1284.4	8.1	L
96.4	8.3	Lt
1303.5	8.8	Lt
03.5	8.4	Vo
04.4	8.8	L
07.5	8.6	Lt
09.5	8.7	Lt
10.3	8.8	Lt
12.3	8.7	Vo
12.5	8.9	Lt
15.3	8.9	Lt

R Bootis

J.D.	Est.	Obs.
242		
1315.7	8.7	L
28.6	8.6	Me
29.7	9.0	M
32.6	9.2	Pi
32.6	9.0	Wpi
34.6	8.9	Hu
35.6	9.4	O
38.6	9.4	Bu
41.6	9.7	Ba
44.7	9.4	Wh
46.7	9.4	Mu
47.6	9.8	S
51.6	10.0	Ba

144918
U Bootis

1334.6	10.0	Hu
34.6	10.5	M
38.6	10.4	Bu
40.7	10.3	V

150018
RT Librae

1341.6	9.5	Ba
52.6	9.1	Ba

150519
T Librae

1352.6	11.4	Ba

150605
Y Librae

1341.6	<12.0	Ba

151520
S Librae

1285.6	8.7	L
1341.6	10.6	Ba

151714
S Serpentis

1352.7	11.8	Ba

151731
S Cor. Bor.

1296.4	8.0	Lt
1303.5	8.0	Lt
07.5	8.0	Lt
09.5	8.0	Lt
10.3	8.0	Lt
11.4	8.0	Lt
12.5	8.0	Lt
15.4	8.0	Lt
32.6	8.7	Pi
32.6	8.8	Wpi
34.6	8.6	Hu
34.7	8.4	M
41.7	9.0	O
51.6	8.9	Ba
52.6	9.6	O

152714
RU Librae

J.D.	Est.	Obs.
242		
1341.6	8.6	Ba
43.6	9.0	Y
52.7	8.8	Ba

153020
X Librae

1343.6	10.5	Y

153378
S Urs. Min.

1289.3	8.5	Lt
96.4	8.4	Lt
1303.4	8.4	Lt
05.4	8.5	Lt
07.5	8.5	Lt
09.5	8.5	Lt
10.3	8.6	Lt
11.3	8.6	Lt
12.5	8.6	Lt
12.5	8.6	Lt
15.3	8.6	Lt
29.7	7.6	M
44.6	8.9	Pi
44.6	8.4	Hu
45.6	8.9	Wh
46.7	8.8	Mu
51.6	8.5	Ba

154428
R Cor. Bor.

1275.7	6.0	L
82.4	6.0	L
83.7	6.0	L
84.4	5.8	L
85.6	6.0	L
89.6	6.0	L
1303.4	6.5	Vo
03.5	6.1	Lt
04.4	6.0	Lt
06.4	6.1	Pe
07.4	6.4	Vo
07.5	6.1	Lt
07.6	6.0	Lt
09.5	6.2	Lt
10.3	6.2	Lt
11.4	6.0	Vo
12.4	6.4	Vo
12.5	6.1	Lt
13.4	6.1	Pe
13.6	6.0	L
15.4	6.4	Vo
15.4	6.1	Lt
15.6	6.3	L
16.6	6.0	Ba
17.4	6.1	L
17.6	6.0	Ba
18.6	6.2	L
18.6	6.1	Ba
22.6	6.1	Nt
22.6	6.3	L
23.6	6.0	Nt

R Cor. Bor.

J.D.	Est.	Obs.
242		
1328.6	6.1	Nt
29.7	6.2	M
30.6	6.6	Wh
30.6	6.7	Cr
31.6	6.5	Me
32.6	5.6	Pi
32.6	6.5	Wpi
33.6	6.0	Cr
34.6	6.0	Hu
34.7	6.3	M
35.6	6.8	Wh
35.6	6.1	Cr
35.6	6.9	Ba
36.6	7.1	Me
37.6	6.5	G
38.6	7.0	Bu
40.7	7.7	V
41.6	7.3	Ba
41.6	7.5	Pi
41.6	7.5	Wpi
41.6	7.2	Bu
41.6	7.4	O
42.6	7.2	Wh
44.6	7.4	Bu
44.6	8.2	O
44.6	7.9	Pi
44.7	8.0	S
47.5	9.0	Ba
47.6	8.7	O
47.6	8.7	S
47.6	8.9	Pi
47.6	9.2	Wpi
51.6	11.0	Ba
52.6	<10.3	O
52.6	11.8	Ba

153536
X Cor. Bor.

1296.5	9.7	Lt
1309.5	9.6	Lt
10.4	9.6	Lt
12.5	9.6	Lt
15.4	9.8	Lt
38.6	11.9	Bu
41.6	<10.8	Pi
41.6	12.0	Ba
42.6	10.0	Wh

154539
V Cor. Bor.

1334.6	8.5	Hu
34.7	9.7	M
38.6	9.5	Bu
41.6	9.1	Pi
41.6	9.3	Wpi
41.7	8.4	Ba

VARIABLE STAR OBSERVATIONS April-May, 1917—Continued.

154615
R Serpentis

J.D. 242	Est.	Obs.
1269.5	8.0	Lt
73.7	7.7	Lt
86.7	6.6	Lt
96.4	6.1	Lt
1303.4	5.7	Vo
03.5	5.9	Lt
05.4	5.9	Lt
06.4	6.1	Pe
07.4	5.7	Vo
07.5	5.9	Lt
09.5	6.0	Lt
10.4	6.0	Lt
11.4	5.6	Vo
11.4	5.9	Lt
12.4	5.6	Vo
12.6	6.0	Lt
13.4	5.8	Pe
15.4	5.6	Vo
15.4	6.0	Lt
38.6	6.8	Bu
41.7	6.4	Ba
47.6	6.8	O
51.6	7.1	Ba

155229
Z Cor. Bor.

J.D. 242	Est.	Obs.
1344.6	<13.2	Y

160021
Z Scorpii

J.D. 242	Est.	Obs.
1341.8	10.7	M

160118
R Herculis

J.D. 242	Est.	Obs.
1332.6	11.6	Pi
32.6	11.4	Wpi
40.7	<11.4	V
41.7	<11.7	Ba
44.6	<11.4	Y

160210
U Serpentis

J.D. 242	Est.	Obs.
1341.7	11.1	Ba
51.6	10.4	Ba

160221
X Scorpii

J.D. 242	Est.	Obs.
1341.8	10.9	M

160519
W Scorpii

J.D. 242	Est.	Obs.
1341.8	<11.2	M

161122 a
R Scorpii

J.D. 242	Est.	Obs.
1341.8	<11.5	M

161122 b
S Scorpii

J.D. 242	Est.	Obs.
1341.8	<11.5	M

161122 c
T Scorpii

J.D. 242	Est.	Obs.
1341.8	10.6	M

161138
W Cor. Bor.

J.D. 242	Est.	Obs.
1286.5	10.5	Lt
96.5	9.5	Lt
1303.6	8.8	Lt
09.5	8.3	Lt
10.4	8.3	Lt
11.4	8.3	Lt
12.5	8.2	Lt
15.4	8.2	Lt
34.7	<11.2	M
41.6	8.8	Pi
41.6	8.6	Wpi
41.7	8.7	Ba
51.6	9.1	Ba

162112
V Ophiuchi

J.D. 242	Est.	Obs.
1352.7	8.4	Ba

162119
U Herculis

J.D. 242	Est.	Obs.
1332.7	<10.9	Pi
33.8	12.2	M
41.7	11.2	Ba
42.6	<11.6	Wh
44.6	12.1	Y

162542
g Herculis

J.D. 242	Est.	Obs.
1303.5	5.3	Lt
07.5	5.4	Lt
09.5	5.4	Lt
10.4	5.3	Lt
11.4	5.4	Lt
12.5	5.4	Lt
15.5	5.3	Lt

162807
SS Herculis

J.D. 242	Est.	Obs.
1283.7	9.9	L
85.7	10.3	L
89.7	10.9	L
1307.6	12.1	L
13.6	12.4	L
22.6	12.1	L
41.7	11.2	Ba
44.6	11.5	Y

163137
W Herculis

J.D. 242	Est.	Obs.
1333.8	11.6	M
41.7	12.2	Ba
44.6	11.6	Hu
44.6	12.0	Y

163172
R Urs. Min.

J.D 242	Est.	Obs.
1321.6	9.2	B
29.7	9.3	M
44.6	9.4	Pi
45.6	9.3	Wh
51.7	9.4	Ba

163266
R Draconis

J.D. 242	Est.	Obs.
1328.8	<10.6	M
36.7	11.6	Wh
41.7	12.2	Ba
44.6	<9.8	S
44.6	<11.6	Pi

164055
S Draconis

J.D. 242	Est.	Obs.
1303.6	8.5	Lt
10.4	8.5	Lt
28.8	8.7	M
44.6	8.7	Pi

164715
S Herculis

J.D. 242	Est.	Obs.
1296.7	8,9	Lt
1303.5	9.1	Lt
09.5	9,3	Lt
12.5	9.5	Lt
32.7	10.0	Pi
32.7	10.2	Wpi
40.9	9.6	M
41.7	10.5	Ba
42.7	10.3	Wh
51.7	11.0	Ba

165631
RV Herculis

J.D. 242	Est.	Obs.
1323.6	11.0	Wh
33.8	10.8	M
41.7	11.0	Ba
44.6	11.0	Hu
51.7	11.0	Ba

170627
RT Herculis

J.D. 242	Est.	Obs.
1341.7	10.9	Ba

171401
Z Ophiuchi

J.D. 242	Est.	Obs.
1340.7	7.7	V
41.7	8.4	Ba

171723
RS Herculis

J.D. 242	Est.	Obs.
1341.7	12.2	Ba
44.6	12.4	Y

173457
TY Draconis

J.D. 242	Est.	Obs.
1313.4	9.1	Pe

175111
RT Ophiuchi

J.D. 242	Est.	Obs.
1340.7	10.3	V
41.7	11.0	Ba

175458
T Draconis

J.D. 242	Est.	Obs.
1344.6	<11.5	Pi

175519
RY Herculis

J.D. 242	Est.	Obs.
1341.7	10.7	Ba

180531
T Herculis

J.D. 242	Est.	Obs.
1333.8	11.4	M
52.7	9.3	Ba

180565
W Draconis

J.D. 242	Est.	Obs.
1345.6	11.4	Wh

181136
W Lyrae

J.D. 242	Est.	Obs.
1286.7	8.4	Lt
96.5	7.8	Lt
1303.5	7.6	Lt
07.5	7.6	Lt
09.5	7.6	Lt
10.5	7.6	Lt
12.6	7.7	Lt
15.5	7.7	Lt
23.7	8.4	Wh
28.8	9.0	M
41.7	9.2	Ba
52.7	10.1	Ba

182224
SV Herculis

J.D. 242	Est.	Obs.
1341.7	12.6	Ba

182306
T Serpentis

J.D. 242	Est.	Obs.
1341.7	10.9	Ba
52,7	10.4	Ba

183308
X Ophiuchi

J.D. 242	Est.	Obs.
1289.7	8.9	L
1318.6	8.8	L
40.9	9.0	M
41.7	8.6	Ba
52.7	8.2	Ba

184134
RY Lyrae

J.D. 242	Est.	Obs.
1344.7	<11.7	Wh

184205
R Scuti

J.D. 242	Est.	Obs.
1283.7	5.2	L
85.7	5.2	L
86.7	5.0	Lt
89.7	5.4	L
96.7	5.3	Lt
1303.6	5.6	Lt
07.6	5.4	L
12.6	5.9	Lt

R Scuti

J.D. 242	Est.	Obs.
1313.7	5.4	L
15.5	6.0	Lt
16.7	5.2	L
18.7	5.3	L
22.6	5.3	L
33.8	5.2	Pi
40.7	5.7	M

190108
R Aquilae

J.D. 242	Est.	Obs.
1289.7	11.1	L
1318.6	10.4	L
52.7	7.1	Ba

190529
V Lyrae

J.D. 242	Est.	Obs.
1328.8	11.0	M
41.8	11.2	M

190926
X Lyrae

J.D. 242	Est.	Obs.
1328.8	8.4	M
41.8	9.2	M
52.7	8.8	Ba

191033
RY Sagittarii

J.D. 242	Est.	Obs.
1322.6	<9.6	L

191350
TZ Cygni

J.D. 242	Est.	Obs.
1352.7	10.9	Ba

192745
AF Cygni

J.D. 242	Est.	Obs.
1296.5	6.8	Lt
1303.5	6,7	Lt
07.5	6.7	Lt
09.5	6.7	Lt
10.4	6.7	Lt
11.4	6.7	Lt
12.6	6.7	Lt
14.4	6.8	Lt
15.5	6.8	Lt

192928
TY Cygni

J.D. 242	Est.	Obs.
1333.8	10.0	Pi
40.8	9.3	M
52.7	11.1	Ba

193449
R Cygni

J.D. 242	Est.	Obs.
1333.8	<11.8	Pi
40.8	<11.8	M

193732
TT Cygni

J.D. 242	Est.	Obs.
1285.7	7.7	L
1313.7	8.3	L
33.8	8.2	Pi
40.8	8,8	M
52.7	7.2	Ba

VARIABLE STAR OBSERVATIONS April-May, 1917—Continued.

194048
RT Cygni

J.D. 242	Est.	Obs.
1333.8	8.6	Pi
40.8	7.6	M
51.7	7.6	Ba

194348
TU Cygni

J.D. 242	Est.	Obs.
1333.8	12.1	Pi
40.8	11.6	M

194604
X Aquilae

J.D. 242	Est.	Obs.
1340.9	9.2	M

194632
χ Cygni

J.D. 242	Est.	Obs.
1275.7	5.2	L
85.7	5.2	L
89.7	5.1	L
96.5	5.4	Lt
1303.5	5.6	Lt
03.5	5.5	Vo
07.5	5.7	Lt
07.6	5.3	L
09.5	6.0	Lt
12.4	5.8	Vo
12.6	6.1	Lt
13.6	5.5	L
14.5	6.2	Lt
15.5	6.3	Lt
33.8	7.0	Pi
40.8	7.9	M
52.7	7.7	Ba

195849
Z Cygni

J.D. 242	Est.	Obs.
1333.8	8.8	Pi
40.8	9.0	M
52.7	8.0	Ba

200212
SY Aquilae

J.D. 242	Est.	Obs.
1341.9	8.9	M

200647
SV Cygni

J.D. 242	Est.	Obs.
1333.8	9.2	Pi
40.8	8.4	M
52.7	8.4	Ba

200715 a
S Aquilae

J.D. 242	Est.	Obs.
1318.7	9.8	L
41.9	11.2	M

200715 b
RW Aquilae

J.D. 242	Est.	Obs.
1341.9	8.9	M

200916
R Sagittae

J.D. 242	Est.	Obs.
1341.9	9.0	M

200938
RS Cygni

J.D. 242	Est.	Obs.
1285.7	7.3	L
1303.5	8.4	Lt
09.5	8.6	Lt
13.7	8.1	L
15.5	8.8	Lt
33.8	8.0	Pi
41.9	8.9	M
51.7	6.9	Ba

201647
U Cygni

J.D. 242	Est.	Obs.
1296.5	7.6	Lt
1303.5	7.4	Lt
07.5	7.3	Lt
09.5	7.3	Lt
11.4	7.3	Lt
12.6	7.2	Lt
14.4	8.2	Lt
15.5	7.2	Lt
33.8	7.0	Pi
40.8	6.8	M
52.7	7.1	Ba

202539
RW Cygni

J.D. 242	Est.	Obs.
1285.7	9.4	L
1316.7	9.5	L
33.8	9.4	Pi
40.9	9.2	M
52.7	8.7	Ba

202946
SZ Cygni

J.D. 242	Est.	Obs.
1271.3	10.0	L
89.7	10.1	L
1318.6	9.8	L
33.8	9.4	Pi
41.8	10.4	M
51.7	8.8	Ba
52.7	8.7	Ba

203847
V Cygni

J.D. 242	Est.	Obs.
1341.8	10.2	M

203816
S Delphini

J.D. 242	Est.	Obs.
1341.9	11.0	M

204016
T Delphini

J.D. 242	Est.	Obs.
1341.9	<11.6	M

204846
RZ Cygni

J.D. 242	Est.	Obs.
1333.8	11.8	Pi
41.8	10.7	M

205923
R Vulpeculae

J.D. 242	Est.	Obs.
1349.9	<11.4	M

210129
TW Cygni

J.D. 242	Est.	Obs.
1341.9	9.4	M

210382
X Cephei

J.D. 242	Est.	Obs.
1333.6	<10.7	Y

210868
T Cephei

J.D. 242	Est.	Obs.
1270.3	6.4	L
84.4	6.5	L
88.3	7.8	Vo
89.2	7.5	Lt
92.2	8.0	Vo
92.3	7.8	Lt
96.3	8.0	Vo
96.4	7.8	Lt
1303.3	8.1	Lt
03.3	8.0	Vo
04.3	7.4	L
05.3	8.1	Vo
05.4	8.0	Lt
07.3	8.1	Lt
09.5	8.1	Lt
10.3	8.1	Lt
11.3	8.1	Lt
11.3	8.2	Vo
12.4	8.2	Vo
12.5	8.1	Lt
14.4	8.1	Lt
15.3	8.1	Lt
41.8	9.0	M
47.7	9.1	S
52.7	9.0	Ba

213044
W Cygni

J.D. 242	Est.	Obs.
1270.3	5.5	L
71.3	5.4	L
1273.3	5.6	L
75.3	5.5	L
80.3	5.4	L
82.3	5.4	L
84.3	5.4	L
85.7	5.3	L
89.2	5.8	Lt
89.7	5.5	Lt
92.3	5.7	Lt
96.5	5.5	Lt
1303.5	5.4	Lt
07.6	5.2	L
09.5	5.5	Lt
10.5	5.5	Lt
12.6	5.5	Lt
13.7	5.0	L
15.4	5.6	Lt
15.7	5.1	L
18.7	5.1	L
22.6	5.3	L

213678
S Cephei

J.D. 242	Est.	Obs.
1341.8	11.3	M
47.7	<10.2	S

213753
RU Cygni

J.D. 242	Est.	Obs.
1271.3	8.7	L
89.7	8.5	L
1318.6	8.7	L
33.8	8.6	Pi
40.9	8.6	M

213843
SS Cygni

J.D. 242	Est.	Obs.
1270.3	8.4	L
71.3	8.7	L
73.3	9.3	L
75.3	10.0	L
80.3	11.0	L
84.3	11.8	L
85.7	11.8	L
89.7	11.5	L
1307.6	11.3	L
13.7	<10.9	L
15.7	11.3	L
16.6	11.2	L
18.6	11.6	L
22.6	11.6	L
33.7	8.2	Pi
40.8	9.7	M
41.8	10.0	M

213937
RV Cygni

J.D. 242	Est.	Obs.
1318.6	6.9	L
33.7	8.1	Pi
40.9	7.7	M

230759
V Cassiop.

J.D. 242	Est.	Obs.
1303.3	9.8	Lt
03.3	10.1	Hd
12.3	<9.8	Hd
13.3	10.8	Pe

235182
V Cephei

J.D. 242	Est.	Obs.
1305.4	6.7	Lt
07.5	6.7	Lt
09.5	6.7	Lt
11.3	6.7	Lt

235350
R Cassiop.

J.D. 242	Est.	Obs.
1289.3	7.8	Lt
1303.3	8.5	Lt
06.3	8.5	Lt
07.3	8.5	Lt
09.5	8.6	Lt
10.3	8.6	Lt
11.3	8.6	Lt
15.3	8.8	Lt
40.9	8.6	M

Var. 21—1913
Geminorum

J.D. 242	Est.	Obs.
1272.42	5.5	L
73.28	5.1	L
75.26	5.7	Be
75.29	5.2	L
76.30	5.1	L
80.28	5.4	L
81.27	5.4	Be
81.28	5.1	L
82.28	5.2	L
82.43	5.3	L
83.32	5.2	L
83.27	5.3	Be
84.27	5.2	L
84.44	5.3	L
85.27	5.3	L
86.26	5.3	L
87.32	5.3	L
88.43	5.3	L
89.28	5.2	L
92.27	5.4	L

No. of observations 1332; No. of stars observed 211; No. of observers 25.

value. In last month's report for the abbreviation "Mc" read "M". Observations contributed by Messrs. Luyten and Vogelenzang and designated "Lt" and "Vo" respectively.

All the irregular variables have been under observation during the past month. The rise of the variables 074922 U Geminorum and 060547 SS Aurigae are recorded. The observations of Messrs. Bouton and Bancroft respectively, in connection with these variables, command attention. The feature of greatest interest, observationally speaking, is the rapid wane of the variable 154428 R Cor. Bor., which has during the month waned from the 6.0 to the 12.0 magnitude. It is at this writing over one hundred times fainter than it was a month ago. Several members noted a slight decrease in its light and a rapid return to the 6.0 magnitude just before the sudden decline began. Messrs. Crane and Whitehorn were the first to call attention to the fluctuation in the light of this star. Truly it is a wonder sun, and of sufficient importance in itself to warrant the closest attention of all our observers, and excite the interest of the world at large. Space does not permit of further comment concerning the many points of interest in the report.

On the evening of May 5th a number of fortunate members and friends of the Association were the guests of Mr. and Mrs. David B. Pickering in East Orange, N. J. A detailed account of this delightful affair appears elsewhere. For the Secretary it was the red letter occasion of a life time. As the recipient of a beautiful loving cup suitably inscribed, from the members of the Association, he takes this opportunity of formally thanking the members for this expression of their good will and friendship, and only hopes that each one may share in the great measure of gratitude he longs to express to each one personally. Surely it is an inspiration to work for such an Association, a priviledge to be associated with such a company of earnest observers, and a pleasure to have been instrumental in founding an organization that has through the bond of a kindred interest and the service of a noble cause fostered in its membership such a true spirit of comradeship.

The following members contributed to this report: Messrs. Bancroft, Benini, Bouton, Bryan, Burbeck, Crane, French, Gray, Houdard, Hunter, Lacchini, Luyten, McAteer, Meeker, Mundt, Nolte, Olcott, de Perrot, D. B. Pickering, S. W. Pickering, Vogelenzang, Vrooman, Whitehorn, Miss Swartz, and Miss Young.

WILLIAM TYLER OLCOTT,
Corresponding Secretary.

Norwich, Conn.
May 10, 1917.

COMET AND ASTEROID NOTES.

Comet *b* 1917 (Schaumasse).—As will appear by inspection of the accompanying diagram, the new comet (*b* 1917), discovered by Schaumasse at Nice on April 25, has already passed its nearest approach to the sun and the earth and is now rapidly vanishing. The elements from which the diagram was prepared were computed by Mr. Einarsson and Miss Young, of the Students' Observatory, Berkeley, California, from observations made on April 28, 29, and May 2. These elements are as follows:

T = 1917 May 18.89 Gr. M. T.
ω = 119° 05′
Ω = 8 49
i = 158 35
q = 0.762

An ephemeris from these elements was given in the Harvard College Bulletin 637 and later in Bulletin 639.

EPHEMERIS.

Gr. M. T.	R. A.	Decl.	Light
	h m s	° ′	
1917 May 6.5	23 20 24	+18 35	1.89
10.5	23 33 19	+24 11	
14.5	23 58 00	+32 42	
18.5	0 53 27	+45 29	8.01
22.5	3 17 5	+58 26	
24.5	5 6 45	+59 02	
26.5	6 37 19	+54 35	
28.5	7 34 55	+48 11	
30.5	8 10 7	+42 01	
June 1.5	8 32 36	+36 47	
3.5	8 47 46	+32 33	

On May 17 the deviation was, in right ascension −37′ 15″, and in declination −24′ 0″.

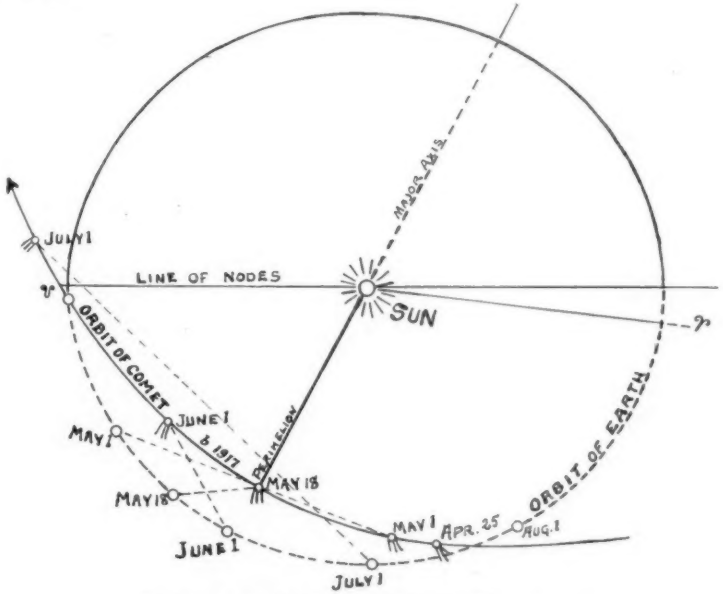

DIAGRAM OF THE ORBIT OF COMET *b* 1917 (SCHAUMASSE).

The following observations are all that have come to hand:

Gr. M. T.	R. A.	Decl.	Observer	Place
	h m s	° ′ ″		
April 28.0055	23 07 39.8	+11 36 57	Shane	Mt. Hamilton
30.9215	23 10 44.26	+13 30 25.6	Pettit	Topeka
May 2.9803	23 13 34.6	+16 05 51	Neubauer	Mt. Hamilton
6.8947	23 21 26.0	+19 03 09	Barnard	Williams Bay
12.8753	23 46 21.33	+28 53 56.8	Barnard	Williams Bay
17.8910	0 43 50.39	+43 39 36.2	Barnard	Williams Bay

Comet *b* 1916 (Wolf).—This comet was observed by Professor Edison Pettit, director of Washburn College Observatory, Topeka, Kansas, on April 30.89; it had a tail 6′ long, in position angle 266°, and a fairly well defined nucleus.

The following elements and ephemeris are given in the Lick Observatory Bulletin No. 295. The comet will be in favorable position for observation all summer, coming to opposition on September 17. It should be at its brightest during the first week in August. For diagram of its path among the stars see the April 1917 number of POPULAR ASTRONOMY.

ELEMENTS OF COMET *b* 1916 (WOLF).

T = 1917 June 16.5373 Gr. M. T.
ω = 120° 36′ 01″.2
Ω = 183 17 50 .4 } 1917.0
i = 25 40 10 .8
log q = 0.227067

EPHEMERIS.

Computed by R. T. Crawford and Dinsmore Alter.

1917 Gr. M. T.	True α	True δ	log Δ	Br.
	h m s	° ′ ″		
June 2.5	21 49 31.4	+20 42 42	0.1142	1.84
3.5	51 46.5	20 54 57		
4.5	54 00.9	21 06 57	0.1101	
5.5	56 14.7	18 41		
6.5	21 58 27.7	30 09	0.1061	1.92
7.5	22 00 40.0	41 21		
8.5	02 51.5	21 52 16	0.1021	
9.5	05 02.2	22 02 54		
10.5	07 12.1	13 15	0.0982	2.00
11.5	09 21.1	23 18		
12.5	11 29.2	33 02	0.0943	
13.5	13 36.4	42 28		
14.5	15 42.7	22 51 35	0.0904	2.08
15.5	17 48.0	23 00 23		
16.5	19 52.3	08 51	0.0865	
17.5	21 55.5	16 59		
18.5	23 57.7	24 46	0.0827	2.15
19.5	25 58.8	32 12		
20.5	27 58.7	39 17	0.0789	
21.5	29 57.5	46 00		
22.5	31 55.1	52 22	0.0751	2.22
23.5	33 51.1	23 58 21		
24.5	35 46.7	24 03 58	0.0714	
25.5	37 40.6	09 12		
26.5	39 33.3	14 03	0.0677	2.29
27.5	41 24.6	18 30		
28.5	43 14.6	22 33	0.0640	
29.5	45 03.5	26 12		
June 30.5	46 50.5	29 27	0.0604	2.36
July 1.5	48 36.3	32 17		
2.5	50 20.7	34 42	0.0567	
3.5	52 03.6	36 42		
4.5	53 45.1	38 16	0.0531	2.42
5.5	55 25.0	39 24		
6.5	57 03.4	40 07	0.0496	
7.5	22 58 40.2	40 23		
8.5	23 00 15.4	40 13	0.0461	2,48
9.5	01 48.9	39 36		
10.5	03 20.8	38 31	0.0426	
11.5	23 04 51.0	+24 36 58		

1917 Gr. M. T.	True α	True δ	log Δ	Br.
	h m s	° ′ ″		
July 12.5	23 06 19.4	+24 34 58	0.0391	2.53
13.5	07 46.0	32 29		
14.5	09 10.9	29 32	0.0357	
15.5	10 33.9	26 06		
16.5	11 55.1	22 10	0.0324	2.57
17.5	13 14.4	17 45		
18.5	14 31.9	12 50	0.0291	
19.5	15 47.5	07 25		
20.5	17 01.2	24 01 30	0.0259	2.61
21.5	18 13.0	23 55 04		
22.5	19 22.8	48 08	0.0228	
23.5	20 30.7	40 41		
24.5	21 36.7	32 43	0.0198	2.64
25.5	22 40.7	24 14		
26.5	24 42.7	15 13	0.0168	
27.5	24 42.8	23 05 42		
28.5	25 40.9	22 55 39	0.0140	2.67
29.5	26 37.0	45 05		
30.5	27 31.2	33 59	0.0114	
July 31.5	28 23.3	22 22		
Aug. 1.5	23 29 13.5	+22 10 13	0.0088	2.68

Brightness April 21, 1917 = 1.00.

Ephemeris of D'Arrests Comet.

Perihelion April 2, 1917.

1917	α	δ	Log *r*	Log Δ
	h m s	° ′ ″		
July 1	3 31 27	+8 24 34	0.21696	0.33226
9	3 49 58	+8 42 46	0.23154	0.33308
17	4 7 21	+8 51 8	0.24606	0.33304
25	4 23 35	+8 50 16	0.26032	0.33198
Aug. 2	4 38 35	+8 40 38	0.27436	0.32991

The above five places of d'Arrest's Comet are based upon Leveau's elements. It will be faint, as it will be about 2.15 units from the earth during July 1917.

Boston, Mass., May 4, 1917. F. E. SEAGRAVE.

Ephemeris of Asteroid Juno.

Opposition July 26, 1917.

1917	α	δ	Log *r*	Log Δ
	h m s	° ′ ″		
July 14	20 33 31	−3 29 11	0.44394	0.25903
18	20 30 23	−3 44 22	0.44234	0.25316
22	20 27 5	−4 2 29	0.44072	0.24825
26	20 23 38	−4 23 13	0.43908	0.24429
30	20 20 10	−4 46 28	0.43742	0.24133
Aug. 3	20 16 41	−5 12 0	0.43574	0.23946

About two weeks ago an astronomer asked me to compute for him a few places of the Asteroid Juno for the coming opposition of July 26, 1917, as the American Ephemeris did not have ephemerides of any of the asteroids. I am sending the figures to you, thinking you may possibly be interested.

Boston, Mass., May 7, 1917. FRANK E. SEAGRAVE.

Ephemeris of (7) Iris.

Opposition July 21, 1917. Nearest Earth July 30, 1917.

1917	α	δ	Log r	Log Δ
	h m s	° ′ ″		
July 1	20 18 26	−14 33 31	0.38654	0.16818
5	20 15 11	−14 31 27	0.38472	0.15978
9	20 11 36	−14 30 42	0.38290	0.15238
13	20 7 43	−14 31 20	0.38106	0.14610
17	20 3 38	−14 33 2	0.37922	0.14099
21	19 59 24	−14 35 47	0.37734	0.13714
25	19 53 7	−14 39 19	0.37546	0.13459
29	19 50 53	−14 43 28	0.37356	0.13341
Aug. 2	19 46 45	−14 48 15	0.37164	0.13342
6	19 42 50	−14 53 21	0.36974	0.13479

CONSTANTS.

$$x = r\,(9.99807)\sin(350\ 31\ 11 + u)$$
$$y = r\,(9.96578)\sin(258\ 17\ 5 + u)$$
$$z = r\,(9.59463)\sin(273\ 16\ 20 + u)$$

ELEMENTS OF (7) IRIS.

Epoch = 1917 July 17.50 Gr. M. T.
M = 282° 21′ 45″.00
ω = 141 31 26 .89
π = 42 5 11 .17
Ω = 260 33 44 .28
i = 5 28 1 .20
Log e = 9.363335
Log a = 0.377712
μ = 962″.58280

I am sending you ephemeris, constants, etc., of the Asteroid (7) Iris for the opposition of July 21, 1917. This asteroid is especially interesting as it seems to vary in the same way as Eros, Eunomia, and several of the other asteroids. Its magnitude will be about 8.7 at the coming opposition.

Boston, Mass., April 30, 1917. FRANK E. SEAGRAVE.

COMMUNICATIONS.

A Suggestion.—If a suggestion would not be out of place I would like to ask if a section in the magazine could not be used to good advantage for the purpose of showing how to construct astronomical instruments, how to grind lenses and perhaps how to build a small observatory to house the instruments of home manufacture? Why more people are not interested in Astronomy is answered in my mind by saying that the construction of the instruments bars the ordinary person from making a beginning. "Lens grinding" is an art which is instilled into the boy's mind as something which it is almost impossible for the human being to attain. I remember how I was in my younger days told by someone who had told them (and I passed it on in good faith) that the polishing was done by the tip ends of the fingers, and it took an *awful* long time. Imagine if you can what effect such a statement would have on giving the ordinary person a start in "lens grinding", "the door to astronomy." I hope every school boy and girl in the land will be given a

chance to try to make their little "spy glasses" and become as familiar with them as they are with their "Wireless sets". Note the difference—magazines show how to make wireless instruments cheaply and Uncle Sam has finally had to make laws to hold the amateurs back. We will have no Professors in astronomy until we have the amateurs. Hoping there is a thought here worth considering

Bourne, Mass., April 23, 1917. RICHARD B. WATERHOUSE.

GENERAL NOTES.

Professor Philip Fox, director of the Dearborn Observatory, and secretary of the American Astronomical Society, has been commissioned as major in the Reserve Officers Corps and is now on duty at Fort Sheridan.

Dr. F. W. Reed, instructor in astronomy at the University of Illinois has also gone to the military training camp at Fort Sheridan.

Professor George E. Hale, director of the Mount Wilson Solar Observatory gave the annual address before the chapters of Sigma Xi and Phi Beta Kappa at the University of Illinois on May 14, his subject being "Whirlwinds and Sunspots". Professor Hale also gave an informal talk on the work of the National Research Council in connection with the National Council of Defense.

Dr. G. Mueller, chief astronomer at the Astrophysical Observatory, Potsdam, Germany, has been appointed director in succession to the late Professor K. Schwarzschild.

Dr. Leo de Ball, author of the well-known "Text book of Spherical Astronomy," died on December 13, 1916, at the age of sixty-three.

General J. A. L. Bassot, director since 1904 of the Nice Observatory, died on January 17 at the age of seventy-five. He was president of the International Geodetic Comission from 1903 to 1916. He assisted in the remeasurement of the arc of the meridian in France and inaugurated a scheme for the revision of the arc of Peru which has since been completed.

Rev. Dr. S. R. Calthrop of Syracuse, N. Y., died on May 1, 1917, in his eigthy-eighth year. He was pastor of the May Memorial Church of Syracuse for 42 years and emeritus pastor for six years. He was much interested in astronomy, especially in the study of sunspots and the forecasting of the weather from their appearance. He had two fine telescopes, one of which was given him by the late E. B. Judson and the other by his church people.

The American Astronomical Society.—The following is taken from the Circular of information issued by Secretary Fox concerning the twenty-first meeting of the Society to be held at Albany, August 29-September 1.

On the invitation of Professor Benjamin Boss and the Trustees of the Dudley Observatory the Twenty-first Meeting of the American Astronomical Society will be held at the Dudley Observatory, Albany, New York, from Wednesday, August 29, 1917 to Saturday, September 1, 1917. The transportation connections to Albany are probably familiar to all members of the Society and need not be mentioned here. The Hotel Ten Eyck has been selected for headquarters. Between this hotel and the Observatory there will be motor bus service. The busses will leave sharply at a stated time, which is hoped to promote promptness in attendance at the meeting. The program is outlined as follows:

PROGRAM.

WEDNESDAY, AUGUST 29, 1917.

9 A. M. Meeting of the Council at the Dudley Observatory
10 A. M. Morning session at Observatory
Lunch at Observatory
2 P. M. Session at Observatory for papers. Committee meetings

THURSDAY, AUGUST 30, 1917.

10 A. M. Session at Observatory for papers
Lunch at Observatory
2 P. M. Session at Observatory

FRIDAY, AUGUST 31, 1917.

10 A. M. Session at Observatory for papers
Lunch at Observatory
1 P. M. Afternoon trip to Saratoga and dinner at Saratoga Lake

SATURDAY, SEPTEMBER 1, 1917.

10 A. M. Session at Observatory and election of officers
1 P. M. Afternoon trip to Poughkeepsie and outdoor supper at Vassar College

The Society will be the guests of the Carnegie Institution of Washington at the three luncheons given at the Observatory. The Society wlil be the guests of the Trustees of the Dudley Observatory on the Saratoga trip. The Society will be the guests of Miss Furness at the outdoor supper at Vassar College.

It is seen that we will here have an opportunity of seeing two astronomical institutions which have not yet been visited by the Society in a body. Some years ago the Society adopted the policy of holding the meetings so far as possible at the various observatories of the country rather than at centers of population. The present meeting complies harmoniously with this principle.

The Total Eclipse of the Sun June 8, 1918.—The Nautical Almanac Office, at the U. S. Naval Observatory, Washington D. C., has issued a supplement to the "*American Ephemeris*" for 1918 which gives considerably more data concerning the total eclipse of next year than is given in the "*Ephemeris*", notably meteorological data gathered in past years from points near the eclipse track and two large charts showing the towns and railroads along the path of totality. This pamphlet may be obtained from the Superintendent of Documents. Government Printing office, Washington, D. C., at thirty cents per copy.

New Zealand Time Signals.—The Hector Observatory of Wellington, New Zealand, is operating a rather novel arrangement of time signals for the benefit of the people of Wellington. The Observatory is on the opposite side of the earth from Greenwich, in longitude $11^h\ 39^m\ 04^s.27$ east, and latitude 41° 17′ 03″.8 south. The signals are given at 20^h, 21^h and 22^h of Greenwich mean time in the following manner:

Three electric lights are mounted vertically on the Observatory flagstaff. The lowest light is green, and is thirty feet above the ground; the middle light is red, and is thirty-six feet above the ground; the highest light is white, and is forty-two feet above the ground. The green light is switched on at 50 minutes, the red light at 10 minutes, and the white light at 5 minutes to the hour; all three lights are extinguished simultaneously at the hour. The switching on of the lights give approximate time signals, the switching off gives exact time.

Meeting of the American Association of Variable Star Observers.

The Spring meeting of the American Association of Variable Star Observers was held on Saturday, May 5th, at the home of Mr. D. B. Pickering, East Orange, N. J. It was an occasion to be long remembered by the members and guests present.

In the afternoon, many exhibitions of the work of the Association were shown, charts plotted with light curves derived from the actual observations of each observer, covering the entire group of variable stars observed by the Association. Special charts covering some of the more important stars, one showing a history for twenty years of continual observation of the variable 213843 SS Cygni, the best observed star of those of irregular type, during which period, not one maximum has been missed since the Association was formed. Another interesting exhibit was that of the plotted curve of the variable 154428 R Cor. Bor., showing fifteen years careful recording of the variations in brightness of this wonderful star, and portraying in a striking manner the present rapid decline of six magnitudes in the light of this star. Before dining, a loving cup, suitably inscribed, the gift of the entire membership of the Association was presented Secretary William Tyler Olcott, as a token of appreciation for the vast amount of work that he has rendered it during the first six years of its existence. The sentiment of this occasion was most aptly expressed in the presentation by Mr. S. C. Hunter.

Later in the evening group photographs were taken by Mr. William Henry of the "New York Herald", who was a guest.

Plans were freely discussed for a formal organization, and a Committee was appointed to draw up a Constitution and By Laws. A list of nominations for officers and Council was made up which will be submitted to be voted upon by all members of the informal Association who express a desire of joining the new organization before the next meeting to be held in Cambridge, Mass., November 10, 1917.

A rising vote of thanks was tendered Mr. and Mrs. David B. Pickering on behalf of the Association for their delightful entertainment, and gracious hospitality, which has been such a factor in inspiring the members to renewed efforts to promote the best interest of our cause.

Many letters of regret from those who were unable to attend the meeting were read. Among them were interesting letters from Professor E. C. Pickering, director of the Harvard College Observatory, Professor H. N. Russell, and Dr. Van der Bilt.

Sunday was very pleasantly spent in viewing the beautiful scenery in the hills of Essex County, N. J.

It seemed to be the opinion of all, and perhaps more forcibly that of those members who have attended several meetings, that these gatherings do a tremendous amount of good, that one cannot but be vividly impressed by the opportunities there are in meeting other members, hearing new ideas, and partaking in the spirit of fraternalism that has so thoroughly bonded the members together.

The following members were present:

Leon Campbell, Cambridge, Mass.
W. T. Olcott, Norwich, Conn.
S. C. Hunter, New Rochelle, N. Y.
Miss H. M. Swartz, S. Norwalk, Conn.
C. Y. McAteer, Pittsburg, Pa.
H. C. Bancroft. Jr., W. Collingswood, N.J.
D. B. Pickering, E. Orange, N. J.
S. W. Pickering, E. Orange, N. J.
C. T. Whitehorn, Bloomfield, N. J.
E. S. McColl, New York City.
W. J. Delmhorst, New York City.
Charles Pardo, New York City.
H. H. Pease, Germantown, Pa.
O. F. Munson, Brooklyn, N. Y.
W. P. Meeker, Roland Park, Md.

Guests, Leon Barritt, New York City, William Henry, Brooklyn, N. Y., R. C Meeker, Roland Park, Md.

A. B. Burbeck.

The Passing of an Observatory.—A clipping from "The Utica Observer" for May 5, gives information of the demolition of the Litchfield Observatory of Hamilton College, Clinton, New York. to make way for a new fraternity hall. This observatory was famous for many years, on account of many discoveries of asteroids, or small planets, made there by Dr. C. H. F. Peters. After his death in 1891, however, no one was appointed to succeed him as director of the Observatory and the building has been allowed to fall into decay. All the instruments of value have been removed from it and stored. The marble pier and the brass of the large telescope are to be sold as old material.

The Litchfield Observatory of Hamilton College Clinton, N. Y.

"In 1857 the first steps were taken to build an observatory. The gifts and subscriptions which poured in were large enough to build the structure 27 feet square, two stories high, and surmounted by a revolving tower 20 feet in diameter.

The best refractor made was purchased, and enough money remained to buy an equatorial. A portable transit and an astronomical clock were given by two alumni and thus equipped, Litchfield Observatory was equalled in this country only by Harvard and Michigan.

"Dr. Peters, who made the observatory well known through his work, was born in Germany in 1813. He received his Ph. D. from the University of Berlin in 1836, being associated in his studies with Dr. Encke, editor of the Berlin Astronomical Almanac. After two years' additional study in Copenhagen, Dr. Peters went to Sicily where he made topographical surveys of Mt. Etna and of the Sicilies, which are still recognized as standards. Becoming interested in the islands, he joined them in their struggle for liberty, and quickly reached the rank of major in Garibaldi's insurrectionists. When the revolt was crushed, Dr. Peters fled to Turkey, where he met the United States Minister to Constantinople, George P. Marsh, by whom he was persuaded to come to America. He settled in Cambridge where he worked on the United States Coast Survey and in the Harvard Observatory. In 1858, Dr. Peters was appointed director of the newly-founded Litchfield Observatory, and he came to Hamilton, where he lived until his death in 1891.

"Dr. Peter's most important work was the observation and charting of the star zones in connection with which he registered over 112,000 stars, and discovered 47 asteroids."

New Variable 211541 —Cygni.—This was discovered by Dr. J. Van der Bilt on the Helsingfors "Carte du Ciel" plates and has been confirmed by Miss Leavitt on the Harvard plates. The observed range of brightness is from 11.7 to 14.5. The position of the variable for 1900.0 is R. A. $21^h\ 15^m\ 09^s$, Dec. $+41°\ 28'\ 14''$.

Variable Star R Coronae.—This variable star, 154428 according to the Harvard nomenclature, was of magnitude 11.4 on May 3, indicating the greatest decrease in its light since July 1911, according to the Harvard Bulletin 636.

Later the following observations by Wilson at Northfield indicate a further decrease in brightness:

Date Gr.M.T.	Julian Day	Mag.
1917 May 9.7	2421358.7	13.2
14.7	1363.7	13.5
17.7	1366.7	13.5
24.7	1373.7	13.4

R Coronae is a very irregular variable. It is ordinarily of the sixth magnitude and frequently remains of constant brightness for a year or more, then within a month its light may diminish by several magnitudes. The star should be watched continually just now.

Variation of the Asteroid (129) Antigone.—Miss Susan Raymond, who holds the Maria Mitchell Fellowship at Harvard, from an examination of photographs taken with the 10-inch Metcalf Anastigmat, has found that the asteroid (129) Antigone is variable, with a range of about four-tenths of a magnitude, and a period of two or three hours. This variation has been confirmed photometrically by Mr. Leon Campbell. (Harvard College Observatory Bulletin 633).

A Memorial to Sir William and Lady Huggins.—The following account of the unveiling of a memorial medallion to Sir William and Lady Huggins is given in *Nature* April 5, 1917. The address delivered by the president of the Royal Society, Sir Joseph Thomson, on that occasion is given in *Nature*, April 19, 1917.

On Thursday, March 29, a representative assembly of the friends and admirers of the late Sir William Huggins, O. M., and Lady Huggins met together in the crypt of St. Paul's Cathedral to witness and participate in the unveiling and dedication of a medallion commemorating conjointly the achievements of a great astronomer and the inspiring efforts of a wife who, for some thirty-five years, identified herself with his aims and labours. Among those present were Sir Joseph Thomson, O.M., president of the Royal Society; Dr. A. Schuster and Mr. W. B. Hardy, secretaries R. S.; Sir Alfred Kempe, treasurer R. S.; Sir Archibald Geikie, O. M.; Major MacMahon, president of the Royal Astronomical Society; the Astronomer Royal; Sir W. Crookes, O.M.; Mr. H. F. Newall; Sir Joseph Larmor; Mr. E. B. Knobel; Sir W. Tilden; Mr. E. W. Maunder; Mr. W. H. Wesley; and the Rev. T. R. R. Stebbing. A number of ladies were also present. After the memorial had been unveiled a short form of service was conducted by Dean Inge, with whom were Canon Simpson and Canon Alexander. In committing the memorial to the charge of the Dean and Chapter, Sir Joseph Thomson paid eloquent tribute to the scientific achievements of Sir William Hnggins. Born and educated in London, and all his work having been carried on and issued from a London observatory, St. Paul's appeared the fittest of destinations for a medallion. Major MacMahon, referring to certain points in a great life, said that Huggins saw celestial chemistry looming in front of him, and before many years had elapsed he was the pioneer of a new branch of science. The medallion of Sir William Huggins, it should be noted, was the primany object of the memorial, but, on the death of Lady Huggins, it was decided to place her portrait beneath that of her husband, on the same slab. Both are the work of Mr. Henry Pegram, A.R.A. The inscriptions run respectively: "William Huggins, Astronomer, 1824-1910"; "Margaret Lindsay Huggins, 1848-1915."

ADDRESS OF SIR JOSEPH THOMSON.

I have been asked, as president of the Royal Society, to commit this memorial of Sir William and Lady Huggins to the care of the Dean and Chapter of St. Paul's, and also to say a few words as to the inception of the memorial. Shortly after the death of Sir William Huggins some of his friends were anxious to set on foot a proposal to obtain a memorial of him; this came to the knowledge of Lady Huggins, and she expressed the wish that she might be allowed to defray all the expenses, so that no one except herself should be put to any expense in the matter. Before any arrangements had been arrived at Lady Huggins died, and it was found that in her will she had left a sum of money to provide for a memorial to Sir William. It seemed to those responsible for carrying out her wishes that in view of the long and active part she had taken in her husband's work, and that some of the most important papers were published in their joint names, no memorial to Sir William would be satisfactory unless it testified in some way to the part Lady Huggins had played in his work; to effect this a small medallion of Lady Huggins had been added as a pendant to the one of Sir William.

There can be no question as to the claim of Sir William Huggins, the founder of astrophysics, as he has been called, to such a memorial, nor any doubt as to where it could most appropriately be placed. For no man of equal scientific eminence was ever more closely connected with this city. He was born in London, he was educated entirely in London, he was in business in London, and when he retired from business to devote himself to astronomy he built his observatory in London; and in spite of the fact that the atmosphere of London is far from being an astronomer's ideal, all the observations which led to the discoveries on which his fame rests were made in London. This great Cathedral seems the appropriate resting-place of a memorial to one whose life and work were so linked up with this city.

Sir William Huggins was a prominent example of a type of man to whom English science owes much, the non-official worker. Like his contemporaries, Darwin and Joule, he never held any professorship or scientific appointment. When in 1858 he retired from business at an unusually early age, he seems to have been undecided as to whether he should devote himself to the microscope or the telescope. The telescope gained the day, and he built an observatory at Tulse Hill; he began by making drawings of the planets, but seemed to be losing interest and to be rather despondent, when Kirchhoff's determination of the chemical elements in the sun by the aid of spectrum analysis came to his knowledge. This was to him, he says, like water in a thirsty land, and he determined to attempt to find out the constitution of the stars by the same method. At the beginning of 1862 he persuaded Prof. Miller to join with him in the work, and in spite of the formidable difficulties due to the feebleness of the light, the mechanical difficulties of keeping the image of the star on the slit of the spectroscope, and the caprice of the London atmosphere, they were able to present to the Royal Society in 1863 a preliminary statement as to the spectra of some of the brighter stars, while in 1864 they published in the Philosophical Transactions of the Royal Society a general account of the spectra of about fifty stars, with a detailed study of some of the more important ones. They showed that the stars are made up of elements which, with few exceptions, are found in the earth. In 1864 Huggins made a discovery of capital importance in connection with the evolution of the stars, for he discovered a nebula the spectrum of which showed that it consisted of glowing gas, and was therefore in quite a different state of development from the stars he had examined, the spectra of which showed that their physical condition was analogous to that of the sun. Huggins threw himself with characteristic energy into the study of the spectra of the nebulæ, and found that the nebulæ were not all of one kind; some were stellar aggregates, while others were continuous masses of incandescent gases.

The importance of these results and the interest they excited were recognised by scientific societies with a promptitude almost without parallel. Three years after beginning serious scientific work he was elected a fellow of the Royal Society, the next year he was awarded a Royal medal, and after ten years he seems to have been elected to almost every scientific society in Europe. The work which commenced with such brilliance was carried on with undiminished ardour for nearly fifty years; since 1875 with the active co-operation of his wife. It showed throughout the characteristics so noticeable in the earlier work: the power to select the right problem to attack, the ability to devise the best way to attack it, and the industry to take boundless pains in overcoming the difficulties which sprang up at every turn.

On behalf of the Royal Society, I record with gratitude the help he gave to the work of that society, and especially to the distinction and dignity with which he for five years discharged the office of president. For the medallion we are indebted especially to Mr. Pegram, the artist whose skill has produced it, and to Miss Montefiore, who has borne the burden of the heavy work necessary to bring such a scheme to completion.

Tapping the Earth's Heat.—As the world progresses, it becomes more and more apparent to students of economics, as well as to the layman, how utterly inefficient and archaic our present coal-burning practice is. There is certainly no greater anomaly than our present coal age, and we may be quite sure that our great grand-children will read with amazement how supposedly intelligent people the world over were using such an expensive make-shift as coal.

There is an excuse for the steel manufacturer using coal when he can mine it at his door. But there is no excuse for a manufacturer or a householder using coal a thousand miles or more distant from the mines. It is simply our present lack of knowledge as well as our gross inefficiency that makes such things possible. First, we mine the coal, compelling men, who could be employed to vastly better purposes, to be imprisoned for life within the bowels of the earth. Then we re-handle the coal a dozen times before we load it on trains. Then we haul it over unbelieveable distances, burning more coal in locomobiles as we go along. Then, if there is no rail blockade, just at the time when coal is needed most, we dump it into someone's yard a thousand miles away from the mine. Next, we load it once more and then sell it to a jobber and he in turn dumps it into another yard. He too sells it again to a dealer who dumps it into his own yard. The dealer, after he has kept it long enough, loads it once more and he also dumps it again, this time into the bins of the ultimate victim. In the meanwhile the coal has been rolling up an avalanche of profits and interest as well as extraordinary expenses in foolish transportation and re-transportation. So at the end of the tortuous road, coal worth $3.00 a ton at the mine, now sells for $7.00 and even $12.00 a ton! It speaks well for us.

But this does not finish the story by any means. After re-handling it a few more times, we now burn the coal and while we do get a little expensive heat, we vitiate the air, poison our lungs, make no end of dust and finally we must dump the burned coal—ashes—once more. And removing ashes costs additional money. Whence we remove ourselves to our library and read the latest magazine which tells us what a wonderfully enlightened race we are. This makes us feel real proud of ourselves.

Of course, happy to relate, the whole world is not peopled by fools. We are slowly beginning to realize that there are other things to give us heat, light and power besides coal. First and foremost we have "white coal"—our waterpower. It costs less to transport horse power by wire than by rail. Thus enlightened Syracuse runs its electric street cars by the power obtained from Niagara Falls, 150 miles distant. And of late the great Chicago, Milwaukee and St. Paul Railroad runs all its electric trains over a distance of 440 miles—not by coal, but by waterpower translated into electricity and led over thin wires along the tracks of the railroad.

But waterpower plants are comparatively scarce. Soon there will not be an untapt waterfall which is not working to full capacity. What then? Our answer comes from Italy. And this time the answer is not visionary, or an editorial pipe dream either. For Prince Ginori-Conti now has a huge power plant located in a volcanic region, which gives him 15,000 horsepower every second of the day as well as during the night. He simply taps the heat of our earth by sinking pipes five hundred feet underground and by this natural heat costing nothing, he obtains heat for his boilers which in turn drive the electric turbo-generators.

What he can do any one can do at *any* point of the globe. True his conditions are favorable, for he did not need to sink his pipes very deep. But great depths are no obstacles to a good engineer to-day.

Speaking generally if we drill a hole straight down into the earth the heat increases 1° Fahrenheit for every 40-50 feet. This means that under adverse conditions we must sink our pipes from 8,000 to 9,000 feet before we will reach a level where we strike 212° Fahrenheit, at which temperature water changes into steam. Huge as such a depth is, as well as huge the cost to reach it, it is not unpractical. Remember it needs to be done only once; after that we will enjoy free power for centuries to come. Moreover, in many localities 212° will be reached at a depth of less than 2000 feet. In exceptional localities such as Yellowstone Park, boiling water comes to the surface while in volcanic regions a few hundred feet is sufficient to sink our pipes.

Would it not pay municipalities to tap the earth's heat under foot and supply the city with heat, light and power at a good profit? Steam heat could be supplied to factories and householders for heating purposes at a low cost by running steam pipes underground. This, by the way, is quite practical altho not widely known. In New York, for instance, one large corporation supplies steam heat to consumers over an area of approximately 1½ miles square (2¼ square miles) thru fifteen miles of steam mains, but of course the heat is now obtained by burning coal first.

Our big states lacking coal and water power should certainly waste no time in trying Prince Ginori-Conti's plan. Such terrestrial heat plants will pay for themselves in two years or less.

H. GERNSBACK in *The Electrical Experimenter*, March 1917.

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